THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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ANNUAL MEETING, NEW YORK CITY, DECEMBER 7-10

THE SOCIETY—ITS OBJECTS AND ACTIVITIES

THE Society was founded in 1880 "to promote the arts and sciences connected with engineering and mechanical construction."

These objects can be accomplished by the promotion of technical research, the dissemination of technical knowledge and literature, and by the betterment of conditions surrounding the profession.

Benefit to the progress of the nation along engineering lines, as well as to the individual engineer, can be most efficiently secured through concerted action along broad lines by an organization of the scope of a national engineering society.

The Society accomplishes these objects through its publications—The Journal and Transactions—through the special Library Mail Service which brings the contents of over 65,000 volumes and 1000 periodicals of technical literature within reach of all engineers regardless of location—through meetings held in fourteen industrial centers of the United States (plans are under way to add new sections during the current year) and thirty-eight Student Branches at the leading technical colleges—and through over thirty-five technical committees at present working to develop the profession.

Total Membership of the Society, October 22, 1915 6648
New Members since January 1, 1915 559

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INTERNATIONAL ENGINEERING CONGRESS

TWO hundred and forty-one papers were presented at the fifty-two sessions of The International Engineering Congress, 1915; and although the present international conditions have hampered somewhat the exchange of all but military engineering thought and experience, sixty-six of the papers contributed were by authors residing outside the United States. In addition to those from our own country, papers were received from Argentina, Australia, Austria, Canada, Chile, China, England, France, India, Italy, Japan, the Netherlands, Panama, Russia, South Africa, Sweden and Switzerland. It is interesting to note that forty-eight authors of papers coming from the United States were members of the Society.

SUBJECTS OF THE CONGRESS

Partial List of Subjects Included in the Papers Presented

Agriculture	Forgings	Pulverized Coal
Alloys	Founding	Railways
Alloy Steels	Fuels	Refrigeration
Aluminum	Grinding	Rivers
Aviation	Heating	Safety
Automatics	Highways	Sanitation
Boilers	Hydraulics	Sewage Disposal
Bridges	Hydroelectrics	Ships
Cargo Handling	Illuminants	Signals
Castings	Iron	Steel
City Planning	Irrigation	Streets
Clay Products	Locomotives	Terminals
Compressed Air	Machine Tools	Testing Materials
Concrete	Management	Timber
Copper	Metallography	Tractors
Docks	Metal Working	Transit
Dust Prevention	Metallurgy	Tunnels
Economics	Mining	Turbines
Education	Motion Study	Utilities
Electrolysis	Navigation	Vehicles
Electric Motors	Ore Dressing	Waterways
Engines	Ordnance	Water Supply
Fire Protection	Panama Canal	Water Wheels
Flood Control	Power Stations	Welding

CONCEPTION AND ORGANIZATION

The Congress was conceived in 1911 when a meeting of representatives of the American Society of Civil Engineers and The American Society of Mechanical Engineers recommended that engineers from the great associations of the world be called together in 1915 to participate in the celebration of the completion of the Panama Canal. A further conference in 1912 led to the formation of plans to hold the Congress in conjunction with the Panama-Pacific International Exposition, 1915. The enterprise was organized and conducted under the auspices of the American Society of Civil Engineers, American Institute of Mining Engineers, American Institute of Electrical Engineers, The Society of Naval Architects and Marine Engineers, and The American Society of Mechanical Engineers. Major General Geo. W. Goethals, the builder of the Panama Canal, was elected Honorary President and nineteen Honorary Vice-Presidents were chosen. Besides its president and secretary, each of the organizing societies elected four representatives on the Committee of Management; the six representatives of the Society on the Committee were Dr. John A. Brashear, Calvin W. Rice, Chas. T. Hutchinson, Thos. Morrin, T. W. Ransom and C. R. Weymouth. Dr. Wm. F. Durand served as Chairman of the Committee of Management; W. A. Cattell as Secretary-Treasurer, and E. J. Dupuy as Executive Secretary. There were six permanent sub-committees of the Committee, as well as six special sub-committees, taking care of the administrative and executive details of the organization.

MEMBERSHIP

To secure for those engineers coöperating in the Congress a permanent record of its proceedings, a plan of membership by subscription was inaugurated, and 3082 enrollments were made, 816 of which were from foreign countries. Each subscriber received the right to participate in the deliberations and privileges of the Congress, and the entitlement to a volume reporting the general proceedings of the Congress and containing indexes and digests of other volumes, and one volume of the transactions.

THE CONGRESS

The Congress opened with a general session in the main hall of the Auditorium Building, Civic Center, San Francisco, on Monday, September 20, at 10 a. m. An address of welcome was delivered by Hon. James Rolph, Jr., Mayor of San Francisco, and other speakers were Maj. Gen. Goethals and the Honorary Vice-Presidents present, as well as Chas. C. Moore, President of the Panama-Pacific International Exposition.

The afternoon of the first day was devoted to a general session on the Panama Canal, six papers being presented, including an Introduction by Maj. Gen. Goethals. There followed during the six days of the Congress, four sessions on Waterways, four on Irrigation, five on Municipal Engineering, five on Railway Engineering, five on Materials of Engineering Construction, six on Mechanical Engineering, three on Electrical Engineering, three on Mining Engineering, five on Metallurgy, seven on Naval Architecture and Marine Engineering, and four sessions devoted to miscellaneous topics including Aviation, Refrigeration, Agricultural Engineering, Engineering Education, and Heating and Ventilation.

The total registration at the Congress during the week was 750. Foreign members and delegates attended from Austria, Australia, Canada, Germany, Switzerland, China, Cuba, France, Guatemala, Japan, Mexico, the Netherlands and Sweden.

THE PAPERS

A complete list of titles of the papers and their authors was included in the full program of the sessions of the Congress published in the September issue of The Journal. The papers covered practically every field of engineering art and the general theme of each was to review recent progress and development in its particular subject and outline the tendencies of present effort. To several of the papers were appended bibliographies, making them a valuable index to the literature of current engineering practice. As members of the Society may be interested in the contributions of their fellow-members, brief synopses of these particular papers are given below; these are listed in the same order as in the program of the Congress, and under the same heads.

The abstracts are taken from the prints of the advance papers given out at the meetings.

BRIEF ABSTRACTS OF PAPERS BY MEMBERS OF THE SOCIETY PRESENTED AT THE INTERNATIONAL ENGINEERING CONGRESS

WATERWAYS

HYDRAULICS OF THE LOCKS OF THE PANAMA CANAL, R. H. Whitehead

This paper discusses the arrangement of valves and culverts and expectation of the design of the Canal locks; observed characteristics of the system and importance of good distribution; discharge through lateral culvert openings when filling locks, neglecting friction; recommendations for design of lateral culverts and their openings; friction losses; discharge through openings corrected for losses; recommendation for total lateral culvert distribution; determination of time equation of flow; filling and emptying curves for Pedro Miguel Lock; calculation of value of dynamic head for complex culvert systems; the rising-stem valves; miter gates and the force required to operate them; current in locks due to difference in salinity.

THE PROVINCE OF WATERWAYS IN THE INTERNAL COMMERCE AND DEVELOPMENT OF A COUNTRY, Brig. Gen. W. H. Bixby

IRRIGATION

ECONOMIC ADVISABILITY OF IRRIGATION, Dr. F. H. Newell

This paper is an exposition of the present condition of development of irrigation practice and an indication as nearly as may be of the principal economic reasons why irrigation has been and should be practiced. It includes a consideration of the causes which have led to the present delay in entering upon or completing large works and indicates some of the lines along which further progress may be expected.

MUNICIPAL ENGINEERING

THE DISPOSAL OF SUSPENDED MATTERS IN SLUDGE, Rudolph Hering

The paper is a discussion of the treatment of the liquid refuse of a city, with special reference to securing healthful results and preventing nuisances from the suspended matter contained in refuse. While it has been known for a long time that inoffensive decomposition of sewage can be secured by efficient aeration, agreement does not yet exist as to the most effective and economical way of applying and diffusing the air.

PUBLIC UTILITIES, Dr. Alex. C. Humphreys

"I am convinced that, under American conditions, the system of private ownership of public utilities is best for the citizens and the consumers," was an expression by Dr. Walton Clark in a minority report to the Commission on Public Ownership of the National Civic Federation. The author reiterates this conviction and devotes his paper to outlining the dangers of unreasonable regulation of utilities.

RAILWAY ENGINEERING

RECENT LOCOMOTIVE DEVELOPMENT, George R. Henderson

Within recent years there have been four distinct lines of advancement in steam locomotives—size, type, details and adjuncts. Utilizing the Mallet principle and adding a driving unit under the tender, we now have running a locomotive of 755,000 lb. adhesive weight and 160,000 lb. tractive force. Cast steel has probably exerted more influence on the design details of the locomotive than any other single item. The increased size and weight of locomotives has brought about

the addition of a number of special features; such are power reversing mechanisms, automatic fire door openers, pneumatic grate shakers, coal pushers and mechanical stokers.

Rolling Stock Other Than Motive Power, Arnold Stucki.

This paper deals with the car equipment used by the railroads of the U. S. and Canada and points out the improvements made during the last decade. These latter have been in the direction of safety and comfort of passengers, strength and efficiency of construction, efficiency in handling freight and in moving trains, and protecting freight. The introduction by the Erie Railroad in 1904 of the all-steel passenger car resulted in an evolution of passenger equipment, and tremendous progress has been made, too, by the use of steel in freight car construction.

The Floating Equipment of a Railroad, F. L. DuBosque

This paper describes in considerable detail the floating equipment of a railroad operating in New York Harbor, that employs 10 ferry boats, 31 tug boats, 7 self-propelled barges, 68 car floats, 71 covered barges, 71 derrick barges and 20 coal barges. The dimensions of the units are given, as well as descriptions and illustrations of them and the service in which they are employed.

MATERIALS OF ENGINEERING CONSTRUCTION

Concrete Aggregates, Sanford E. Thompson

While uniform Portland cement is now manufactured at low cost, the other principal ingredient of concrete, the aggregate, has not been thoroughly standardized. Series of tests have been made, and are still in progress, for the clearer formulation of laws of concrete mixture. On account of the variation in strength of mortars made with different sands, sand and other aggregate should always be tested. Strength; permeability of the mortar and concrete; effect of different brands of cement; effect of frost action; effect of fire; characteristics of yield, density, chemical composition, mechanical analysis and amount of organic matter, are factors which should be considered.

Alloys and Their Use in Engineering Construction, W. Reuben Webster

The paper is more particularly devoted to the most extensively employed group of alloys of which copper is the base. It discusses the physical properties and characteristics of the brasses and bronzes and of the alloys containing copper, zinc, lead and tin, usually known as red brass and varying in strength, toughness, cost, color and machining qualities according to their composition.

Testing Full Size Members, Gaetano Lanza

This paper is retrospective, considering the meaning and scope of the term *Testing Full Size Members;* the importance of making such tests and the reasons therefor; the need for their performance on a systematic and well organized plan, so that the results obtained may be of the greatest value in engineering practice; an enumeration of the kinds of tests that have thus far received the most attention; a summary of the tests most needed, including a consideration of certain classes of tests concerning which comparatively little, and of others concerning which no progress has been made thus far, and a consideration of the value and possibilities of coöperation in making full size tests.

MECHANICAL ENGINEERING

Recent Advances and Improvements in Founding, Thomas D. West

Since the introduction of electricity and compressed air as a motive power, improvements in the construction of foundries and their appliances have been steady and persistent. In keeping with the improvements for handling raw materials are those for mixing, melting, molding, core making and cleaning of castings. The production of ferrous and non-ferrous metals has been greatly assisted by chemical studies. The advancement in core making and molding has been due to the use of molding machines. The cleaning of castings by sand blasting, pneumatic and hydraulic tools, and electrical appliances has progressed. Labor saving appliances and the adoption of specializing have operated to improve materially the quality of castings.

Forgings from Early Times to the Present, C. von Philp

The different methods of producing forgings are hammering, pressing and squeezing, extruding, die-casting and bending. With the development of the steam hammer, with its valve gear, the size of forgings made by hammering has been greatly increased. The art of die forging has developed to such an extent that all kinds of intricate forgings that could never be thought of in the days of the early methods can now be made. Owing to the high speed of the modern hydraulic forging press, this can now compete with hammers in producing forgings of even comparatively small size. The extruding process is being used in the manufacture of pipes and wires of lead, shapes in brass, valves of high grade steel, rods, etc. Carburetors and instruments are being manufactured by the die casting method which has taken quite some time to develop. Bending was mostly employed for flanging boiler heads, but with the advent of the steel railroad car, bent forgings have been found more economical than structural shapes; they are also largely used in the shipbuilding trade.

Permanent Shops, Pacific Terminals—Panama Canal, H. D. Hinman and A. L. Bell

Machine Shop Equipment, Methods and Processes, E. R. Norris

The greatly increased feeds, speeds and depths of cut rendered possible by the use of Taylor and White's high speed steel made it necessary for the builders of machine tools to redesign their tools along heavier lines and with greater pulling power, and later to equip the machines with quick changing and automatic attachments to facilitate the handling between cuts. The paper considers special alloy steels, their composition, treatment, application and effect on machine shop practice; machining with edge tools; grinding as a final machining operation and electric driving for machine tools.

Machine Shop Equipment, Methods and Processes, H. F. L. Orcutt

This paper reviews the progress in American and European machine tools in the last fifteen years. As the most important improvements, the author selects single pulley drive, change gear boxes, independent motor drive, ball and roller bearings, speeding up idle movements, provision for cutting and cooling fluids, better lubrication, increased precision, chain drive and rigidity in design. He describes in detail recent advances in grinding, gear cutting and tooth finishing, and auto chucking machines.

Automatics, R. E. Flanders

From an early period lathes and, later, drilling machines have been provided with self-actuating feeds, and are thus automatic. As self-actuating feeds became the rule, something more was required to justify the use of the term, which has of late years only been applied to machine tools in which practically all the movements are self-actuating. The multiple spindle automatic screw machine is now firmly established, but the large multiple spindle automatic lathe is still a new venture. Milling machines, drill presses, gear cutting machines, grinding machines furnish other examples of automatics used in American machine shop practice.

The Internal Combustion Engine of the Year 1915. The Gas Power System. A Survey of Its Status in 1915, Prof. C. E. Lucke

After a fifteen-year period of close study of performance, design, construction and adaptation to service, the internal combustion engine and the gas power system occupy to-day a definite place in the scheme of industrial affairs and are so firmly established that they will never be replaced. To-day the internal combustion engine is thermally more efficient, size for size and fuel for fuel, than the steam engine in any size in which it can be built, and the difference in fuel combustion is greater the smaller the size because efficiency of steam systems fall off very rapidly with decrease of size, while the internal combustion engine does not.

With the present state of knowledge on the properties of explosive mixtures and the distillation, vaporizing, gasification and combustion of fuels, the first fundamental step in the design of gas engines for specified performance is on a truly scientific basis.

Mechanism designers and power engineers are devoting attention to the mechanical perfection of apparatus operating on the two adopted cycles, the Otto and the Diesel, both of which have high enough efficiency characteristics both promised and realized for some time to come.

The Diesel Engine in America, Max Rotter

This paper includes historical and fundamental information regarding the Diesel, or high compression constant pressure oil engine, and the so-called semi-Diesel, or low compression oil engine. It compares the 2-cycle and the 4-cycle types. It considers the design details of Diesel engines, including fuel atomizing elements, cylinders and heads, pistons and accessories and lubrication. A part of the paper is devoted to the consideration of fuels and in another are mentioned and briefly described several Diesel type engines built in the United States. Typical indicator diagrams, both maximum and no-load, are given, enabling comparisons to be drawn, and the details described are well illustrated.

Water Wheels of the Pressure Type, Arnold Pfau

This paper is divided into eight chapters—theoretical definition of pressure wheels; previous and present art; applicability; classes, types and characteristics; description and selection of type; efficiencies and tests; accessories, and some general remarks and suggestions—a knowledge of the basic principles of water wheels is presumed. Wheels are classified according to the direction of flow of the water with reference to the shaft, as follows: radial outward discharge, diagonal outward discharge, axial discharge, diagonal inward discharge, radial inward discharge, and combined radial or diagonal inward axial and diagonal or radial outward discharge; a history of each of these classes is given.

The Francis turbine, the types of runners for which are now elaborately classified, has displaced all other types of reaction turbines and manufacturers now offer these turbines of large capacities for heads as high as 1000 ft. With a single runner, vertical shaft turbine, efficiencies can be obtained which exceed 90 per cent.

Water Wheels of Impulse Type, W. A. Doble

Safety Engineering, Frederick R. Hutton

Of the phases of the problem of industrial safety, the mechanical engineer is directly concerned with the prevention, by safety apparatus and otherwise, of accidents originating from the sudden injury to the body through the motor forces in industry. Complete safety at the origin of power calls for engine stops; lattice cages safeguard workers from the moving parts of engines. Belts and pulleys and chain drives are guarded with sheet steel or lattice, as are moving parts of machines and individual tools.

The forge and the rolling mill, the steel works and the blast furnace, the saw mill and the chemical process plant, the textile mill and the dye-house, the electric furnace and the power transmission line and switches—each offers its own problems and all have found their satisfactory safeguards.

Motor Vehicles; Utility Type, Arthur J. Slade

These are defined as self-propelled vehicles designed to be operated without rails, for the primary purpose of transporting materials, products, passengers or apparatus, especially for business purposes or for fire, profit, emergency work or special utility service; as distinguished from private personal use by the owner or renter for enjoyment or convenience.

The paper presents the results of the author's observation of the development, during the past decade, of the general types of commercial motor cars which have to any marked extent become standardized, and gives the present status as to features of design and application, and the tendencies of future development. The storage battery electric and the internal combustion engine driven vehicle are first considered, and special application of each or combinations of both are then referred to.

Compressed Air in the Arts and Industries, W. L. Saunders

The forcing of compressed air through the molten metal in the Bessemer converter, and the consequent decarbonizing action has made this method of steel making possible. To the forced draft in the boilers of vessels may be, in part, attributed the high power developments in restricted space for boiler capacity, as illustrated in naval practice, in torpedo boats, destroyers, etc. Bellows, rotary fans, blowing engines, rotary blowers, steam jet blowers, and other similar appliances are now used in the ventilation of mines, of buildings and generally in the removal of vitiated gases and in the supplying of gases and air for chemical purposes. Diving apparatus, bells, caissons and tunnel shields play a most important part in the field of engineering. Compressed air-operated locomotives are becoming generally employed. The employment of compressed air has solved the problem of braking railway trains. The pneumatic despatch tube as a conveyor has come into wide use. A pneumatic gun of 15-in. bore has been developed. The Whitehead torpedo is

driven by compressed air. In mines and quarries a large central compression plant has come to be accepted as the most effective means of providing power.

ELECTRICAL ENGINEERING

The Effect of Hydro-Electric Power Transmission Upon Economic and Social Conditions, with Special Reference to the United States of America, Frank G. Braun

The stability of any civilization depends on the fact that it consumes less than it produces, and as with an increasing population, the most efficient methods must be employed for all operations, nature's naturally replenished sources of power must be used instead of consuming wood, coal, oil, etc.; and the most natural source of power is falling water, which nature is annually producing. This water power, converted into the electric form for distribution and supplied to electric appliances for conversion into the form desired, at the place desired, is the most efficient and convenient system imaginable.

The author expects to see central stations of 100,000 kw. and trunk transmission lines constructed to connect a large number of these stations throughout the continent, with branch substations and lines over the entire country. The prime movers will be limited to water wheels located at favorable water power sites and steam turbines at sources of cheap fuel, coal, oil or gas.

Electrical and Mechanical Installations of the Panama Canal, E. Schildhauer

Electric Welding, C. B. Auel

There are three clearly defined processes of electric welding—arc, incandescent and electro-percussive—each more or less limited to a certain field. The first includes the Zerener, Bernados and Slavianoff processes; the second, the La Grange-Hoho and the Thomson processes.

The arc processes are autogenous, in that welding can be accomplished without pressure, simply by allowing the metals to melt under the influence of the electric current, then to mix and unite as they cool; the incandescent and electro-percussive processes, however, invariably require pressure as a necessary adjunct to their successful accomplishment. The paper compares these processes and considers their applications.

The Electric Motor as an Economic Factor in Industrial Life, David B. Rushmore

The present highly developed civilization is dependent upon the utilization of the stored energy in our natural resources or upon the energy from the sun, either directly or through water powers; and the utilization of this energy on a broad scale has been economically possible only by the use of electricity.

Electricity is the most convenient form in which to transmit and apply energy, and the electric motor produces motion and torque at various speeds and in different directions.

The paper discusses the various types of electric-motor designs and gives examples of their applications. It outlines the fields of electric motor application.

The Influence of the Electric Motor on Machine Tools, A. L. DeLeeuw

The electric motor has influenced the machine tool beneficially along the following lines: better knowledge of the data governing the design of machine tools; greater possibilities in regard to power; closer control of a machine tool in regard to speeds, stopping, starting, etc.; flexibility of the use of machine tools, by making them portable and by making a better shop construction possible. The most marked and beneficial influence of the electric motor on machine tools has been the bringing into view of the lack of fundamental knowledge of machine tools, and it has opened up a new era—which may be called the scientific era—for the machine tool.

Effect of Electrolysis in Engineering Structures, Albert F. Ganz

The principal engineering structures which may be effected by electrolysis from stray electric currents are electric railway tracks, and iron or steel structures supporting these tracks; underground lead sheathed cable systems; underground piping systems and steel foundations of buildings, bridges, etc., and reinforced concrete structures. The paper give information, based on the writer's personal experience and on direct inquiry, illustrating cases of and remedial measures applied to affected structures.

MINING ENGINEERING

The Valuation of Anthracite Mines, R. V. Norris

The problem of valuation of coal in the anthracite region in northeastern Pennsylvania is complicated by the rapid variations in the thickness and quality of the beds, by the numerous faults and still more numerous convulsions. The basins are traversed by endless anticlinals and synclinals, and within short distances good coal is changed to crushed and worthless dirt. The value of anthracite land has rapidly increased, until at the present time \$3,000 per acre is considered only a fair price for good virgin coal land. In 1907 great advances were made in assessed valuation, and assessments imposed have been resisted in the courts; at the present time assessed valuations of \$175 to \$300 per foot-acre are attempted to be imposed.

Organization and Staff of Mining Companies, W. H. Shockley and R. E. Cranston

METALLURGY

Improvements in Design and Construction of Modern Copper Plants, Chas. H. Repath

The rapid progress and development in mining and smelting in modern times has been due to the general development in all the arts and sciences and the increase in the general intelligence of the men who are engaged in this class of work. Mechanical appliances have been perfected and adapted to the problem of handling materials in every department and new machinery invented to do work that originally took large numbers of laborers. Nearly all large companies maintain experimental and testing departments, in charge of which are competent engineers and metallurgists, who are engaged constantly in the development of new processes and in perfecting the old ones that are used in the treatment of ores and in the conservation of the values that were previously wasted.

METALLURGY

THE DEVELOPMENT OF ELECTROLYTIC COPPER REFINING, Lawrence Addicks

Three distinct stages in the development of copper refining may be noted: early development; tonnage extension, and efficiency work. The first period ends with the development of mechanical ladling, general use of cranes for handling electrodes and the undertaking of the building of the Raritan Copper Works in 1898. The second period covers the next six years, which saw the creation of the first really large plants; and the third, the ten years just closed, with plenty of work yet in sight to put refining on a finished basis.

Both the series and the multiple processes have given relatively pure bullion and there is little to chose between them. However, the multiple process is much less sensitive to impurities and requires less skill in operation, and has been adopted by those later entering the refining business.

SURFACE COMBUSTION (WHAT IS IT?), C. E. Lucke

NAVAL ARCHITECTURE AND MARINE ENGINEERING

RIVER, LAKE, BAY AND SOUND STEAMERS OF THE UNITED STATES, Andrew Fletcher

This paper includes authentic drawings of the midship cross sections with scantlings, deck plans, elevations and a data sheet of general dimensions, draft, displacement, trial speed and motive power of a number of well-known and successful steamers of the United States. The steamers selected are of the steamboat type, with the exceptions of the turbine steamers "Yale" and "Harvard"; the steamer "Governor Cobb," the first Parsons marine-turbine steamer built in the U. S., and the turbine steamer "Belfast."

SPECIAL TYPES OF CARGO STEAMERS FOR THE U. S. COAST TO COAST TRADE THROUGH THE PANAMA CANAL, Geo. W. Dickie

The character of the inter-coast trade demands a special type of vessel. The type demanded by part of the East-bound freight and all of the West-bound is not suitable for the economical transportation of lumber, which is the predominating part of the East-bound. The paper describes a vessel combining the good qualities of both the shelter-decker for general cargoes and the lumber steamer, and sacrificing the special functions of neither. Some of the objects are accomplished by making the lumber type of vessel deeper in the hold, adding a middle deck, carrying the hatches up through the deck load by making a continuous trunk for them, making in effect a partial shelter-deck type.

THE SUBMARINE, L. Y. Spear

SOME ECONOMIC FUNDAMENTALS OF FREIGHT HANDLING, D. B. Rushmore

This paper gives a general outine, from an economic as well as an engineering standpoint, of the problems involved in freight handling, and discusses scientific methods of investigation, analysis and construction as the necessary means of solution of these problems. These problems have to do with the installation of mechanical apparatus in present terminals and for use with present ships, cars and warehouses; the development of ports and harbors and location and design of docks, terminals and warehouses; as well as the attempted standardization of package sizes. The field offers attractive possibilities for central station power loads and is one which will develop in the near future.

FUEL OIL, Ernest H. Peabody

THE APPLICATION OF DIESEL OR HEAVY OIL ENGINES TO MARINE PROPULSION, G. C. Davidson

The paper outlines the status of the Diesel engine as applied to marine propulsion today, and includes examples of present types of engines.

The Nobel Company was the pioneer in applying Diesel engines to marine purposes. Long before oil engines were used on ships in other countries, the Nobels had a fleet of Diesel-engine ships in operation in Russia. The Burmeister and Wein Company has been very successful in applying its heavy 4-cycle engines to merchant vessels.

MISCELLANEOUS

AGRICULTURE AND THE ENGINEER, J. B. Baldwin

A large part of agricultural production involves many mechanical operations not dissimilar to those used in the factory. Agricultural engineering embraces farm machinery, farm power, farm structures, rural sanitation, manufacture of agricultural products, drainage, irrigation and public roads. The first four of these relate more directly to the farm, and are naturally of more recent development, while the last three relate to the agricultural community and have reached a higher state of development. The paper outlines the field for the agricultural engineer and discusses the training required.

SOME CONSIDERATIONS REGARDING ENGINEERING EDUCATION IN AMERICA, G. F. Swain

This paper discusses the general tendency and development of engineering education in this country. It outlines the elementary curricula of the early engineering schools, the graduates of which built our railroad systems and many of our great municipal works. It considers the difficulties of the more complex requirements and methods of today and suggests they may best be met by cutting off from the top of our present too elaborate and too widely expanded curricula, and in offering the bachelor's degree for a more general course in engineering science and the humanities, in which fundamental principles rather than practical applications are emphasized.

TECHNICAL EDUCATION FOR THE PROFESSIONS OF APPLIED SCIENCE, Ira N. Hollis

This paper relates to the professional side of applied science and discusses the methods in vogue in this country for training young men for the technical professions. It gives a schedule of studies in American technical schools, comparing the courses in three representative institutions; mechanical engineering schools are selected on account of the workshop courses. It concludes with a discussion of the theories of education as relating to the success or failure of a technical school, and a consideration of these theories applied to the modern American technical college with its mixture of undergraduate and professional studies.

DEVELOPMENTS AND PROGRESS IN "SCIENTIFIC MANAGEMENT" DURING RECENT YEARS, E. P. Lesley

MOTION STUDY AND TIME STUDY INSTRUMENTS OF PRECISION, F. B. Gilbreth and L. M. Gilbreth

This paper is for the purpose of disseminating knowledge

of the methods and devices of waste elimination, particularly as to the devices used for making the measurements that enable waste to be eliminated. It outlines and illustrates methods of making time studies or processes of analyzing an operation into its elementary operations and observing the time required to perform them; and motion studies having to do with the selection, invention and substitution of the motions and their variables that are to be measured.

HEATING AND VENTILATION

Heating and Ventilation, Introductory Paper, R. C. Carpenter

Vacuum, Vacuo-Vapor and Atmospheric Heating Systems, J. D. Hoffman

An analysis of the great changes in the methods of steam heating in the past twenty-five years shows that steam pressures in radiators and coils have dropped from 50 to 60 lb. gage to atmosphere and below. The most recent tendency towards simplicity is an atmospheric, two-pipe, gravity return system, with radiators controlled at inlet and open to atmosphere on end of return.

The paper describes in detail modern mechanical vacuum, vacuo-vapor and atmospheric systems and includes illustrations of the special fittings upon which the efficiency and satisfactory working of these systems are largely dependent.

THE VOLUMES OF PROCEEDINGS

It is planned to issue the volumes of proceedings between November and January, and members of the Society who did not enroll in the Congress, but who wish to obtain any or all of its publications, should communicate with E. J. Dupuy, Foxcroft Building, San Francisco, Cal. The final arrangement of publication is: Vol. 1, Panama Canal; Vol. 2, Waterways and Irrigation; Vol. 3, Municipal Engineering; Vol. 4, Railway Engineering; Vol. 5, Materials of Engineering Construction; Vol. 6, Mechanical Engineering; Vol. 7, Electrical Engineering and Hydroelectric Power Development; Vol. 8, Mining Engineering; Vol. 9, Metallurgy; Vol. 10, Naval Architecture and Marine Engineering; Vol. 11, Miscellaneous, including Aeronautics, Refrigeration, Agricultural Engineering, Engineering Education, Heating and Ventilation, Scientific Management.

SOCIAL AND ENTERTAINMENT FEATURES

On the evening of the opening day, a reception was tendered by the Committee on Management to the Honorary President, Vice-Presidents, delegates, members and guests of the Congress. This was held at the Palace Hotel.

A trip was made to Mount Tamalpais by some of the members and guests on Tuesday morning, while on Wednesday afternoon a party was conducted through the Panama-Pacific International Exposition by the local members of the Committee of Management.

In honor of the members and ladies, a lawn party was given in the Faculty Glade, University of California, on the afternoon of September 23, and an automobile ride to points of interest in San Francisco was tendered the visiting ladies on the following afternoon.

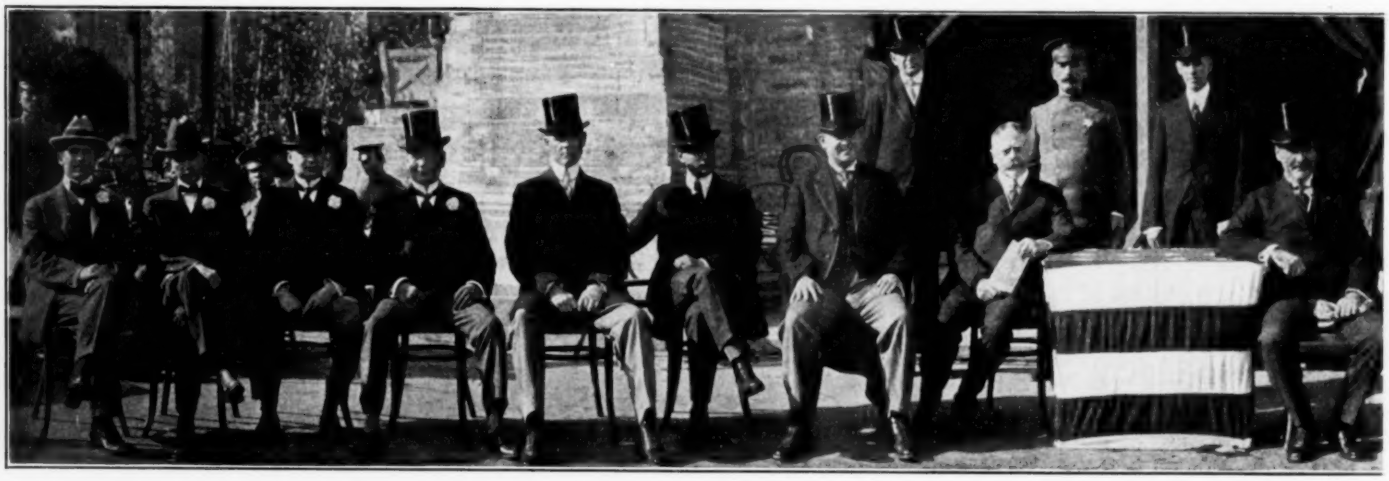
The President and Directors of the Panama-Pacific Exposition designated Friday, September 24, as Exposition Engineers' Day. The delegates to the Congress with their ladies were invited to take part in the ceremonies held in the afternoon in the Court of Abundance in honor of the members of the engineering profession who had rendered especially distinguished service to the Exposition. On this occasion bronze plaques were presented to the nine engineers who built the Exposition. Preceding the ceremonies a luncheon was tendered the engineers in the Directors' quarters of the California Building.

On Friday evening a banquet at the Palace Hotel was given to the officers, delegates and members of the Congress and their ladies. Three hundred covers were laid. Prof. Durand acted as toastmaster, and the foreign vice-presidents were represented by Major Jean L. de Pulligny, of the French army. Brig. Gen. W. L. Sibert spoke in place of General Goethals, who had been called away to New York.

By the courtesy of the State Harbor Commission, Jerome Newman, Chief Engineer, a cruise and inspection trip was made along the San Francisco water front on Saturday, September 25, giving members an opportunity of inspecting the harbor and engineering works along the front.

THE RETURN EAST

For the purpose of showing members of the Congress the engineering works along the line of the Canadian Pacific Railway and the wonderful scenery through the Canadian Rockies, a special train leaving San Francisco on September 25 was run over the lines of the Southern Pacific and Canadian Pacific Railways to Chicago. This train took the members of the party through Portland to Seattle, where a Canadian Pacific Ry. steamer carried them to Vancouver. Here they were entertained royally by the British Columbia Electric Railway Company, Limited, and inspected the company's Coquitlam-Buntzen Hydro-Electric Development which provides electric energy for the city of Vancouver and other cities in lower British Columbia. Continuing through Ruskin, North Bend, Glacier, Lake Louise and Banff, the party arrived at Calgary on Monday, October 4. They were here the guests of the city, were entertained at luncheon at which the Mayor gave an address of welcome, and were shown by the City Engineer the new bridges and the headgates of the Canadian Pacific irrigation system. The big dam at Bassano was the last engineering objective, and the party passed from there through Moose Jaw and Minneapolis, arriving in Chicago on Thursday, October 7.



Left to right—L. F. LEUREY, assistant electrical and mechanical engineer of the Exposition; H. D. DEWELL, chief structural engineer; SHIRLEY BAKER, assistant director of works; H. D. H. CONNICK, director of works; C. S. SCOTT; WM. H. CROCKER, chairman of committee on buildings and grounds; THEODORE JOHN A. BRASHEAR; Prof. C. D. MARX; J. J. CARTY; C. C. VOGELSANG, commissioner; F. L. HUTCHINSON; CALVIN W. RICE; Lieut.-Commander C. H

ENGINEERS' DAY AT THE PANAMA-PACIFIC

ENGINEERS' DAY AT THE EXPOSITION

Friday, September 24, was Engineer's Day at the Panama-Pacific International Exposition. Ceremonies were held in the Court of Abundance, and the purpose of the gathering was well expressed in the remarks of Wm. H. Crocker, Chairman of the Building and Grounds Committee, who spoke as follows:

We are assembled here to-day, in this beautiful place, for the purpose of honoring nine of the engineers who worked faithfully in the construction of this Exposition. The Exposition officials wish to pay them special recognition and have chosen the time of the convening of the Engineers' Congress in order to signal these nine engineers who worked for the Exposition, in a more permanent manner than otherwise would be adopted. The work which these engineers did will never be forgotten. They had a great responsibility. It was due to their careful work that we were able to adjust our finances, adjust the work that was to be done, and so to handle the construction of the work as to make it possible under their direction. They did their work faithfully and well. They did their work within the appropriation and they accomplished it on time. I wish to mention emphatically the names of those who did this wonderful work. They are Harris D. H. Connick, Director of Works; A. H. Markwart, Assistant Director of Works; Guy L. Bayley, Chief Mechanical and Electrical Engineer; E. E. Carpenter, Chief Civil Engineer; Shirley Baker, Construction Engineer; H. D. Dewell, Chief Structural Engineer; William Waters, Superintendent of Construction; W. M. Johnson, Engineer of Fire Protection; L. F. Leurey, Assistant Chief Mechanical and Electrical Engineer. I cannot emphasize too greatly the importance of the services of these gentlemen, and in order to show them the gratitude the Exposition officials feel toward them jointly and severally, President Charles C. Moore will present to each one of them a token of this occasion.

President Moore, referring to the occasion as the "recognition of the engineering profession," and expressing the sentiments of the Exposition in well chosen words, thereupon presented each of the engineers named with a beautiful bronze plaque of Florentine design and inscribed with the legend "This is in Recognition of Services as One of the Engineers of the Panama-Pacific International Exposition, by its Board of Directors, on Exposition Engineers' Day, September 24, 1915." President Moore concluded with the hope that in the records of the engineering societies represented, mention would be made of these men who had honored the Exposition by their enthusiastic, conscientious and most efficient service.

PRESENTATION AT THE PANAMA-PACIFIC INTERNATIONAL EXPOSITION, OF COMMEMORATIVE MEDAL TO DR. JOHN A. BRASHEAR, PRESIDENT OF THE SOCIETY

The Panama-Pacific International Exposition presented a commemorative medal to Dr. John A. Brashear, as Pennsylvania's most notable citizen, at a ceremonial held in the Court of Abundance, on Wednesday, September 22, which day had been designated by the President of the Exposition, Charles C. Moore, as Brashear Day.

Colonel A. G. Hetherington, Director of Art, Pennsylvania Commission, took the chair and opened the proceedings with these remarks:

We are assembled here for the purpose of honoring a Pennsylvanian, who has been chosen as one of the most beloved, if not the most beloved, of the men of our state. He comes here representing nine millions of people. He has been honored all over the world, but the gewgaws that have been given to him are nothing, because he has, with his great genius, journeyed throughout the Heavens, with its illimitable space. He has within him the heart of a child and the agility of a boy, both physically and mentally. After

chief of construction; W. O. WATERS, superintendent of building construction; GUY L. BAYLEY, chief mechanical and electrical engineer; A. H. MARKWART, HARDEE; CHARLES C. MOORE, president of the Exposition; JOHN A. BRITTON, vice-president; CARL S. HERMAN; DR. F. J. V. SKIFF, director in chief; DR. WOODWARD, U.S.N.; CHARLES WARREN HUNT; HOWARD H. HOLMES, consulting engineer of the Exposition.

INTERNATIONAL EXPOSITION, SEPTEMBER 24, 1915

the presentation of the Commemorative Medal to him by Director Brown you will hear him speak. I will not detain you longer, and thank you for coming here to see our great Pennsylvanian.

FRANK S. BROWN, Director of the Exposition, in behalf of President Moore, then presented the medal to Doctor Brashear, saying in part:

It is my great pleasure and high privilege to welcome here to-day Pennsylvania's most distinguished citizen, and to pay tribute to the genius of the man who has made not only his own state, but the nation illustrious.

Doctor Brashear is a man whom all the world honors for his accomplishments and above all for that sweet courtesy and kindliness of heart that has endeared him to his friends and to the people of Pennsylvania. When we consider his accomplishments and how he has made possible for those of us who walk on this earth to behold the wonders of the Heavens and to get our inspiration from the planets that are moving through infinite space, surely we can say that to Doctor Brashear may be applied George Eliot's attribute: "The world is but made better for his presence."

We of the Exposition feel that we owe a great debt of gratitude to the engineering profession and to those who have representatives in our councils here—a debt of gratitude we can never repay, because we owe to the engineering profession the rebuilding of the city of San Francisco. It was said, after that great destruction of our city, that it would take years merely to remove the ruins, and you who live here know that in less than three years the city was practically rebuilt. It was said also that it was impossible to build the Panama Canal; in fact, as long ago as 1534 the first Panama Canal Commission appointed by the King of Spain reported to the King that there were not men enough and money enough in any nation in the world to undertake such a great accomplishment!

So we of the Exposition, we of California, and we of this nation want to honor our distinguished citizens, such as Doctor Brashear, feeling that in doing this we are honoring and dignifying the nation itself. We delight in honoring the citizens whom our great commonwealth has selected as its foremost citizen; a man of accomplishment; a man whose sole purpose has been for the benefiting by his life the human race; a man who, without hope of reward or thought of reward, has consecrated his life to the work of uplifting humanity in order that the world might be improved by his presence.

So, in behalf of the Board of Directors of this great Exposition, it is my high privilege to-day to present to Doctor Brashear this bronze medal, typifying as it does the efforts of the human race for more than four centuries in the development of the civilization on the western coast, the efforts of the people of the United States in the completion of the Panama Canal that made possible the linking of all the world together, the energies of the people of San Francisco in the rebuilding of their city, and last, but not least, the building of this magnificent Exposition, which commemorates the achievements of such men as Doctor Brashear and the men of the engineering profession, and so, Doctor, I ask that you accept in behalf of the President and Board of Directors of the Panama-Pacific International Exposition this bronze medal, carrying with it our love, our gratitude, and our appreciation of what you have done for this nation.

Doctor Brashear, in accepting the medal, said he could not conceive why the State of Pennsylvania had gone into the rolling mill and selected a mechanic as its leading citizen, when it had such men as Russell Conwell and John Wanamaker. He continued:

I must, however, say a few words of appreciation of the very kindly address that our good friend has given us in presenting me this medal. His words of praise are far more than I deserve, and far more than I shall be able to acknowledge in my response.

What I best love to say is that, although we may be great engineers, great scientific men or women, but whatever we are, it is our duty to have something else to do, as our good friend Mr. Brown has said, for the uplift and betterment of humanity, and the man or woman who cannot leave a record of having done something of the kind for the world, has lived in vain.

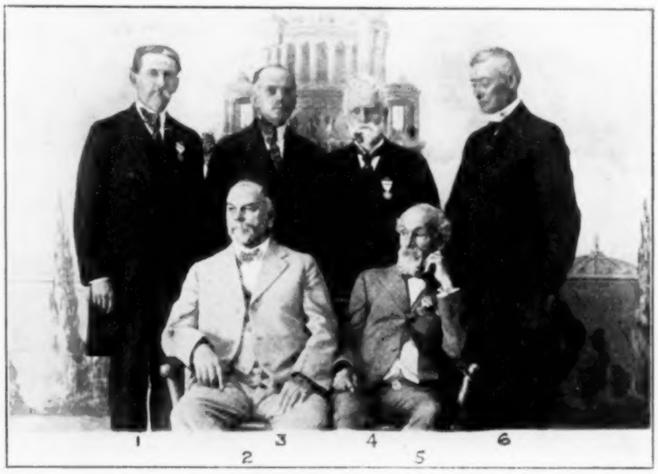
"It may be only a glad good morning
As we pass along the way,
But it will leave a ray of sunshine
Over the live-long day."

I want everybody to go from this place and forget me, but think of the other fellow, whom you can help out of the shadow into the sunlight of this old world. You can all do something. There is a greater accomplishment than that performed by our good friend Brown and his associates in the construction of these magnificent Exposition buildings—a greater work than we engineers and you officials have done in your calling—a greater work than the building of the Panama Canal, which has connected the two oceans. It is ours to break down the conditions that are damning this old world of ours by war, by affliction, by suffering, and by death. You and I can help to do it, every one of us. Let us all, whether we get medals or not, do what we can to make this old round world run smoother on its bearings, by pouring the oil of joy upon them rather than the spirit of heaviness.

Colonel Hetherington said there was no doubt that the Governor of California would be glad to be there, if it were possible, but he had sent a representative. He then introduced Mr. Arthur Arlett.

Mr. Arlett, speaking for the State of California, then addressed the company:

Of course, representing for the moment the State of California, any man with the heart and spirit and vision of this, our honor guest, is counted as one with us; for if there is one thing that we have been trying to establish in this commonwealth in these later years it is this—that the thing of supreme value in all the world is human personality and that that which transcends all other things, talent, finance, commercial greatness, is the human spirit. But with such a man as this, we say as men in California we find in you a fellow worker and a wondrous leader in our great task. To say a word or two, which might be formal, but which cannot really be so in this presence, I wish to say on behalf of our Governor, and as far as I may on behalf of the people of the State, that to this man who so thoroughly typifies that old and wonderful truth that "A child shall lead them" and has demonstrated to us that the surest sign of greatness is simplicity—to this man then we desire to render what homage we may. He feels a sentiment too great for words; he finds, I am sure, that our hearts' desire breaks through and escapes as with true fellowship, beyond any phrase, and beyond any word that human lips can utter.



1 James Hartness, Past-President, Am.Soc.M.E.
2 Worcester R. Warner, Past-President, Am.Soc.M.E.
3 William Gerry Morgan, M.D., Washington, D. C.
4 Ambrose Swasey, Past-President. Am.Soc.M.E.
5 John A. Brashear, President, Am.Soc.M.E.
6 Charles Burckhalter, Director, Chabot Observatory, Oakland, Cal.

Group of Notable Men at the International Engineering Congress

R. L. Countryman, a former citizen of Pennsylvania but resident in California, then spoke:

Pennsylvania has sent from its great borders men and women to preach patriotism and brotherly love, the brotherly love that is so highly typified by the great city of Philadelphia. We people of Pennsylvania, who have left that state for various reasons, retain our admiration and respect for it. We may love California, we may love the Pacific Coast, but still we may also love Pennsylvania.

Doctor Brashear has many accomplishments. His connection with the scientific world has been such that he has been elected into almost all of the renowned societies in the world as an honorary member or as an active member. He is a practical man; in other words, he calls himself a "greasy mechanic." He is a Doctor of Science. It seems also that he has literary accomplishments. He is a scientist—that has been recognized by all the scientific societies in the world. In addition to that, the one thing that most appeals to me in the Doctor is his ability as a maker of astronomical instruments. They say he can make the finest instruments of any man on the face of the earth; and any man who can bring to us the stellar system, so that we may understand the why and wherefore of life, is certainly entitled to be honored by any people.

I remember Professor Bernard, who was formerly at Lick Observatory, taking me to the observatory on the hill when he was in San Francisco, and fixing a clock and glass so that at a quarter of an instant after eight o'clock I would see a certain star. I watched the clock and the star appeared on time. There was no question of delay, there was no question of any lack of ability to reach conclusions. Now, why is this system so perfect? That is the thing that the great astronomers, the men of science, are trying to determine for us to-day and to my mind the highest accomplishment, the greatest ability, is shown in the capacity of the various men who are studying and enabling us to study the solar system to ascertain the effect and cause of it.

We believe that the scientist should be encouraged, that the man who can tell us the mysteries of this system, star for star, and planet for planet, is the man whom we should want to revere; and so to-day, as Pennsylvanians, we are proud to say that we honor the great son of that state who is here today, representative of our great Keystone State. We feel his thoughtful way is leading men on upward to better things, and that the great state of Pennsylvania has reason to be proud that it can name as its most useful citizen, as its most distinguished citizen, the honored guest of this occasion.

THE APPROACHING ANNUAL MEETING

All the Annual Meeting papers, with the exception of three or four in the hands of committees, are being printed in pamphlet form for advance distribution. Copies of any or all papers will be sent to any member in advance of the meeting upon request. The prospects are that pamphlet papers will be available early and that members who are intending to contribute written discussions will have ample time to prepare them.

The program of the meeting is now completed except in one or two minor particulars and is announced below. This early announcement will enable members living at distant points and who intend to come to the meeting to make their arrangements in advance.

The social features of the meeting will be the reception and the dinner and dance for members and their ladies and guests, and the smoker for members.

One business meeting and seven professional sessions will be held and on one afternoon, excursions have been arranged to points of exceptional interest.

This is the seventieth general meeting of the Society and the thirty-sixth annual convention. It is hoped that all members will find it possible to attend and take part in the deliberations, and so contribute to the success of the meeting. The attendance at annual meetings has been increasing steadily, and last year the attendance was a record one.

PROGRAM

Tuesday Evening, December 7

Opening Session: Address by Dr. John A. Brashear, President of the Society.

Reception by the Society to the President, President-elect, ladies, members and guests.

Wednesday Morning, December 8

BUSINESS MEETING

Reports of the Council and Standing Committees. Constitutional Amendments. Announcement of Report of Power Test Committee. New Business.

Immediately following the business meeting, the Society will honor the memory of the late Dr. Frederick W. Taylor, Past-President. The proceedings will consist of a report by a special committee appointed by the President to represent the Society at the Taylor Memorial Meeting held in Philadelphia on October 22 under the auspices of the Society to Promote the Science of Management.

PROFESSIONAL SESSION

Papers to be presented by title only

GAS PRODUCERS WITH BY-PRODUCT RECOVERY, Arthur H. Lymn

THE APPLICATION OF ENGINEERING METHODS TO THE PROBLEMS OF THE EXECUTIVE, DIRECTOR AND TRUSTEE, Hollis Godfrey, Mem. Am. Soc. M. E.

MODERN ELECTRIC ELEVATOR AND ELEVATOR PROBLEMS, David Lindquist

These three foregoing papers contributed by the New York local committee

TURBINES VS. ENGINES IN UNITS OF SMALL CAPACITIES, J. S. Barstow

Contributed by the Philadelphia local committee

THE CONNORS CREEK PLANT OF THE DETROIT EDISON COMPANY, C. F. Hirshfeld, Jun. Am. Soc. M. E.

Contributed by the Buffalo local committee

PROPORTIONING CHIMNEYS ON A GAS BASIS, A. L. Menzin, Assoc. Mem. Am. Soc. M. E.

The foregoing papers which are to be presented by title will be distributed at the meeting in pamphlet form, and written discussion upon them solicited for publication in The Journal. There will be no opportunity for oral discussion of these papers.

STEAM POWER

Papers to be presented by abstract

DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS, F. W. Dean, Mem. Am. Soc. M. E.

HIGHER STEAM PRESSURES, Robert Cramer, Mem. Am. Soc. M. E.

A NOVEL METHOD OF HANDLING BOILERS TO PREVENT CORROSION AND SCALE, Allen H. Babcock

This paper in preliminary form was presented before the San Francisco local section, December, 1914

Wednesday Afternoon

SIMULTANEOUS SESSIONS

RAILROAD

Papers contributed by the Sub-Committee on Railroads

OPERATION OF PARALLEL AND RADIAL AXLES OF A LOCOMOTIVE BY A SINGLE SET OF CYLINDERS, Anatole Mallet, Hon. Mem. Am. Soc. M. E.

FOUR-WHEEL TRUCKS FOR PASSENGER CARS, Roy V. Wright, Mem. Am. Soc. M. E.

Other papers to be announced

TEXTILE

Papers contributed by the Sub-Committee on Textiles

HEATING BY FORCED CIRCULATION OF HOT WATER IN TEXTILE MILLS, Albert G. Duncan, Mem. Am. Soc. M. E.

Other papers to be announced

MACHINE SHOP

Papers contributed by the Sub-Committee on Machine Shop Practice

ELECTRIC OPERATION AND AUTOMATIC ELECTRIC CONTROL FOR MACHINE TOOLS, L. C. Brooks, Jun. Am. Soc. M. E.

REPORT ON CODE FOR ABRASIVE WHEELS

Other papers to be announced

Wednesday Evening

SMOKER

A departure will be made from the usual Wednesday evening lecture, by holding a Smoker in the rooms of the Society, to which all members are invited. This will be a get-together, get-acquainted meeting, in charge of the New York local committee, to which every member is invited for a social evening and a good time.

Thursday Morning, December 9

SIMULTANEOUS SESSIONS

POWER PLANT

THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERING, L. B. McMillan, Jun. Am. Soc. M. E.

PERFORMANCE AND DESIGN OF HIGH VACUUM SURFACE CONDENSERS, Geo. H. Gibson, Mem. Am. Soc. M. E., and Paul A. Bancel, Jun. Am. Soc. M. E.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS, Paul A. Bancel, Jun. Am. Soc. M. E.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS, Mark A. Replogle, Mem. Am. Soc. M. E.

MISCELLANEOUS

THE FLOW OF AIR THROUGH THIN-PLATE ORIFICES, Ernest O. Hickstein, Jun. Am. Soc. M. E.

This paper is the Junior Prize paper for 1915, and bears the further distinction of being the first paper to receive a prize from The American Society of Mechanical Engineers. A fund for Junior and Student prizes was recently established by a member of the Society.

ELASTICITY AND STRENGTH OF STONEWARE AND PORCELAIN, James E. Boyd

Contributed by the Research Committee

FOUNDATIONS, Charles T. Main, Mem. Am. Soc. M. E.

Contributed by the Sub-Committee on Industrial Building

OIL ENGINE VAPORIZER PROPORTIONS, Louis Illmer, Mem. Am. Soc. M. E.

Thursday Afternoon

This afternoon is left free for excursions. Instead of providing for a large number of excursions, as in previous years, the Local Committee has arranged for a few of exceptional interest which it is expected large groups of members and guests will attend.

Thursday Evening

Annual Reunion, Dinner and Dance at Hotel Astor.

Friday Morning, December 10

INDUSTRIAL SAFETY

Papers are in preparation, of which definite announcement will be made later, on the following subjects:

Safety Standards in Industrial Establishments

Modern Movement for Safety from Standpoint of Manufacturer

Methods of Reducing Accidents Through Coöperative Movements with Workmen

Compulsory Compensation for Accidents by Law

This session is under the direction of the Sub-Committee of Protection to Industrial Workers.

ABSTRACTS OF PAPERS

Abstracts of the papers to be presented at the Annual Meeting will appear in this and the next numbers of The Journal. These abstracts, while brief, will serve to furnish members with an adequate idea of the contents of the papers, and will be of assistance to any member in selecting those papers of particular interest to him and to the discussion of which he might desire to contribute.

GAS PRODUCERS WITH BY-PRODUCT RECOVERY

BY ARTHUR H. LYMN

The object of this paper is to present an historical resumé of the development of the by-product producer gas industry in Europe.

As far back as 1883, Young and Bielby in England claimed to recover in the form of ammonia from 60 to 70 per cent of the total nitrogen in the fuel, and although their retort was heated from the outside instead of the air and steam blast being superheated this ammonia recovery is not far short of what we realize to-day.

Two years later Dr. Mond first put into commercial practice his process of gasifiying fuel by means of steam and air and simultaneously recovering the ammonia. Up to 1897 Dr. Mond was constantly endeavoring to improve his process, but after that time he appeared to be satisfied with its design.

E. J. Duff, whose interests were afterwards amalgamated with Dr. Mond's into the Power-Gas Corporation, brought out a plant which differed from the Mond plant only in the design of the superheater. Several large Duff plants were constructed.

The next improvements were claimed by Crossley Bros., who introduced a plant in which the washing and cooling of the gases, as well as the condensing of the water vapor and the absorption of the ammonia took place in one and the same appparatus.

The author replaced the irksome towers of these early plants by a system of vertical washers. He substituted steel for lead in the parts of the ammonia absorbing apparatus, and made improvements in the removal of dust by adopting a cyclonic dust separator of somewhat special design.

In the gas producer itself, mechanical agitation in the fuel and ash zones and mechanical ash removal were introduced. Modifications of this system applied to ammonia recovery plants resulted in a vastly increased volume of air and steam, a deeper fuel bed, superheating of the blast, increased blast pressure and consequently deeper water lute.

Ammonia recovery plants have been applied for power as well as for heating purposes. Power gas and by-products are now regularly produced from peat containing up to 60 per cent water.

APPLICATION OF ENGINEERING METHODS TO THE PROBLEMS OF THE EXECUTIVE, DIRECTOR AND TRUSTEE

BY DR. HOLLIS GODFREY, MEM. AM. SOC. M. E.

This paper is an endeavor to determine the methods by which the service of a consulting engineer may be made of greatest value to the executive of a corporation, or to a board of directors or trustees, during the interregnum in an executive office. After an experience of several years, the author has found the following method of value.

(*a*) The defining, on the basis of facts shown by engineering study, of the policies of a business.

(*b*) The expression in simple usable form of the definitions obtained.

(*c*) Construction on the basis of studies made.

Money saving and money making, time saving and improvement of service are all intimately connected with proper definition and expression of facts about a business.

The consulting engineer who is serving a corporation should present to the executive a general preliminary coöperative study of the field to determine what lines are most worthy of study, a coöperative determination of what facts should be known about these lines, a careful collection and intensive study of the facts existing in the lines chosen, the translation of the facts collected in the light of their relation to the other departments of the business, the expression of the facts studied and a method for the constructive use of the facts obtained.

The coöperative engineering adviser to an executive must be able to distinguish clearly between records which are vital to the future policies of a business and those which are merely historical; the past in industry as a determinant for policies is of value only as it is vitally concerned with the future. He must omit many engineering refinements, to avoid doing work that costs more than it is worth. He must check his work with the practical needs and limitations of the business. He must keep abreast of the "best of the art." He must have a wide acquaintance with professional men and must be able to bring to bear upon the problem before him the best that science and industry have yet produced.

MODERN ELECTRIC ELEVATOR AND ELEVATOR PROBLEMS

By David Lindquist

This paper is an interesting treatise on the problem of the modern electric elevator in its bearing upon the construction of tall buildings in the large cities. It is a clear analysis of building elevator practice in general and points out the steps in the development of electric elevator practice, wherein the traction type of electric elevator has come to replace all of the earlier highly developed hydraulic types. The possibility of locating the traction elevator machine at the top of the hatchway has, it is shown, been a powerful factor in its development.

The problems that have attended the development of the traction electric type are outlined, including those of roping, counterweight and rope compensation, construction of the motor, armature shaft bearings, power consumption, and safety devices. The electrical achievement in the design of a motor capable of operating efficiently at 60 r.p.m. and less, is, of course, responsible for this radical design of elevator machine, but incidentally, this form of design affords unusual opportunities for interesting and very efficient methods of braking and control.

In the consideration of the power consumption of this type, careful attention is given to the character of the service handled in numerous specific cases. The requirements for elevator service in tall buildings in the large cities are, in fact, so exacting that only by the most effective control, as is afforded by a traction type of machine, can satisfactory service be given; the traction design is shown to lend itself readidly to quick starting and stopping, and rapid rates of travel between floors.

The author concludes with detailed reference to a new form of safety device which has been worked out in connection with the application of elevators of this type to the high-speed, high-rise service. The requirements for safety devices in this class of service are pointed out, and the interesting constructional details, by means of which the various requirements are fulfilled, are described.

TURBINES VS ENGINES IN UNITS OF SMALL CAPACITIES

By J. S. Barstow

The author limits the term "units of small capacities" to steam turbines and engines of less than 500 h.p. capacity, and an effort is made to point out the fields within this range where the small turbine is of conceded superiority, and likewise the other fields wherein the engine must hold sway. Within the past few years, the practicability of the small turbine has been definitely established, and with it results are shown that in many cases exceed those obtainable with the engine.

In comparing the two types of prime movers, the author considers them with regard to: *a.* Speed conditions and limitations; *b.* Steam pressure and temperature conditions; *c.* Power capacity of turbines; *d.* Relative space requirements; *e.* Use or application of the exhaust steam; *f.* Available cooling water supply; *g.* Operating conditions; *h.* Relative cost of complete installations.

The paper concludes with a classification under the headings: direct connected units, condensing; direct connected units, non-condensing; and geared units, indicating the classes of service under which each of the two types is more applicable.

THE CONNORS CREEK PLANT OF THE DETROIT EDISON COMPANY

By C. F. Hirshfeld, mem. am. soc. m. e.

This paper is a discussion of the power plant problem of the Detroit Edison Company in the City of Detroit, whose phenomenal growth as a result of an unusual industrial development has brought interesting questions to the company. It became evident in 1912 that greatly increased power producing capacity would soon be required, and after an extended consideration of the requirements of the distribution system in its relation to the present large plants at Delray, it was decided to construct a large new additional power plant at the opposite end of the city. In connection with this decision, interesting statistics are presented relative to the growth of population of the city, the increase in the annual power output, and of the load factor.

The reasons that decided the interesting layout at the Connors Creek site are discussed, and the opportunities for introduction of interesting features of design are outlined. The arrangement for coal and ash handling, and the construction for future development were effective in bringing about a most unusual design of plant and equipment.

Special mention is made of the large boiler units and their layout in relation to the turbine units operated from them; two of these boiler units are installed to supply each of the 25,000 k. v. a. turbo-generator units. The details of the steam piping and other auxiliaries are described, with special reference to the jet condenser equipment used in connection with steam driven auxiliaries for feed water heating. The paper concludes with a description of the electrical system with its switching and control equipment.

PROPORTIONING CHIMNEYS ON A GAS BASIS

By A. L. Menzin, assoc-mem. am. soc. m. e.

This paper reviews the subject of calculating the proportions of chimneys, taking into account the increasing tendency to operate boilers at higher overloads, the attention being given to baffling as a factor in improving boiler performance and the efforts to improve the efficiency of combustion, resulting in a reduction of the volume of gases to be removed.

It considers mathematical expressions for deducing the effective draft and height of a chimney; for determining the maximum draft produced by a chimney; for finding the draft

required to produce a change of velocity of the chimney gases; for calculating the loss of draft due to sudden enlargement of gas passage; for expressing the friction loss in breeching and chimney, and for arriving at the draft required at the boiler damper. It describes the method of converting boiler horse power into gas volume to enable the utilization of the principles discussed, and illustrates the application of the formulae and data for calculating chimneys on a gas basis by working out a practical problem in detail.

DESIGN OF FIRE TUBE BOILERS AND STEAM DRUMS

By F. W. Dean, mem. am. soc. m. e.

This paper considers what makes steam boilers dangerous and how certain parts should be designed in order to make them safe. It is intended as an extension of the Society's work, through its Boiler Code Committee, in devising rules for the construction and care of steam boilers.

The great and usual cause of weakness in boilers is the bending of some part first one way and then the other with the appplication and removal of pressure, causing cracks. This part is usually the longitudinal joint, and the lap form of this joint has been a prolific cause of explosions. Butt joints, properly designed, have practically eliminated this cause.

A detail of boiler making which needs more careful attention is that of bending plates.

Boiler head braces should be supported so as to prevent movement in any direction, instead of merely supporting the weight.

In riveting, the best practice is undoubtedly to drill all holes from the solid.

A conical course in the outside firebox of a vertical boiler is preferable to a reversed flange. The latter bends backward and forward under pressure, and is liable to crack.

Dished heads "breathe" with changes of pressure, causing them finally to crack round the flange. Such heads should be made thinner and braced like flat heads.

Tight brickwork is desirable to prevent the leak of air, with its harmful effect on draft and economy.

Horizontal return tubular boilers, no matter what their length or size, should be supported at no more than four points. The three-point principle of supporting boilers is the best, and this effect can be obtained and yet have the boiler held up at four points by connecting two points to an equalizing lever working on a pin passing through overhead supporting beams.

HIGHER STEAM PRESSURES

By Robert Cramer, mem. am. soc. m. e.

Theoretical considerations, based on the laws of thermodynamics, point out that the economy of steam engines and turbines could be further improved by increasing steam pressures over those now commonly in use. The probable gains for different conditions are given graphically and in tabular form.

Practical difficulties arising from the problems of design and operation of engines, turbines, boilers, and fittings are broadly discussed and the conclusion is reached that higher steam pressures should prove practical and profitable.

OPERATION OF PARALLEL AND RADIAL AXLES OF A LOCOMOTIVE BY A SINGLE SET OF CYLINDERS

By Anatole Mallet, hon. mem. am. soc. m. e.

The author undertakes in the paper an analysis of the many attempts that have been made for the transmission of power to convergent axles of locomotives from a single set of steam cylinders. In the discussion, the mechanisms on records for this purpose are divided into two classes: *first,* those involving elements having rotary motion, and *second,* those involving elements having reciprocating motion. In the first class it develops that there are several examples on record that utilized gear transmissions of interesting form, while another group made use of endless chains; a third group has driving mechanism consisting of universal joint connections between trucks, a form of construction most applied in the United States.

Of the class utilizing reciprocating motion, many interesting examples are quoted. These are divided in the following groups: Those operating connecting rods located in the longitudinal axis of the engine; those coupling by oscillating levers or equalizers; those using free axles; those using external connecting rods of which the length varies with the convergence of the axle.

FOUR-WHEEL TRUCKS FOR PASSENGER CARS

By Roy V. Wright, mem. am. soc. m. e.

There are four important factors which demand attention in the designing of trucks for railway passenger cars. These are, in the order of their importance, safety, smooth riding, minimum weight and low cost of maintenance. The Pennsylvania Railroad uses four-wheel trucks for carrying much heavier passenger cars than do most of the other railroads in this country. The paper deals with the development of the modern steel four-wheel truck for passenger service on that system, giving particular attention to the degree to which it meets the above requirements.

ELECTRIC OPERATION AND AUTOMATIC ELECTRIC CONTROL FOR MACHINE TOOLS

By L. C. Brooks, jun. am. soc. m. e.

In the early application of electric motors to machine tools, the motors were started by hand starters. While there are a number of cases in which these starters are still more applicable, we have reached the time when automatic starters, remote controlled, are the most suitable.

Some of the advantages of automatic control are: The operating switch is easily attached to the machine and the main panel may be located at a distant point. The starting time of the machines is automatically regulated to suit the load conditions on the motor. Accurate stopping points are obtained by "dynamic braking."

All panels should be provided with fool-proof enclosing cases, meeting applicable safety-first requirements, for protecting the appliances from injury and the operator against accidental contact. All automatic starters and control apparatus should be provided with protection from low voltage on the line, also from excessive overload.

The three general types of automatic starters are *time element, counter E.M.F.* and *current limit.* Starters for small motors consist of line contactor, overload relay, field rheostat and connecting board. For larger motors, where one step of resistance is necessary, they include line switch and fuses, contactor, C. E. M. F. accelerating contactor and connection board. For still larger motors the latter is modified to accommodate the additional accelerating contactors.

At the present time, the problem of purely automatic control for general lathes has not been entirely solved, although lathes for a special class of work have been controlled with safety and efficiency. Automatic control equipment has been applied to boring mills, planers, and slotters.

Not the least important factor for a successfully operating electrically controlled machine is the motor. For small printing presses, ventilating fans, small machine tools, woodworking machines, etc., the shunt motor is applicable and for adjustable speed work it is suitable for planers, boring mills, heavy lathes, etc. The series motor should always have a certain friction load and is thus applicable to centrifugal pumps, cranes and hoists.

SAFETY CODE FOR THE USE AND CARE OF ABRASIVE WHEELS

During the year 1914 a committee of the National Machine Tool Builders' Association studied the question of a Safety Code for the Use and Care of Abrasive Wheels. This report was presented before the Worcester meeting of this association, following which representatives of abrasive wheel manufacturers conferred on the matter and made certain modifications, based in part on a tentative report on the subject by a special committee appointed by the State of Pennsylvania. The Sub-Committee on Machine Shop Practice of the American Society of Mechanical Engineers has considered this revised report and made further suggestions and now submits the code with these features added for discussion at the Machine Shop Session of the Annual Meeting.

THE HEAT INSULATING PROPERTIES OF COMMERCIAL STEAM PIPE COVERINGS

By L. B. McMillan, jun. am. soc. m. e.

While an enormous amount of effort has been expended in attempts to determine accurately the savings effected by the use of non-conducting coverings on steam pipes, little information is on hand regarding the efficiencies of pipe coverings in commercial use at the present time. Most of the early results of tests apply at only one temperature or two at most, and for one or two thicknesses; they are not applicable to modern conditions involving high superheat and thicker coverings.

The paper describes an investigation of the effect on heat losses of varying the temperature difference between pipe surface and air, between the limits of 0 and 500 deg. fahr. Different thicknesses of material from 0 to 3 in. were tested and the laws confirmed. The drops in temperature from steam in a pipe to the inner and outer surfaces of the pipe wall under various conditions were accurately determined.

A new fact brought out was that the loss from any covered pipe is a function of the temperature difference between the surface of the covering and the surrounding air, and this function is the same for all coverings having the same character of surface regardless of what the other properties of the covering may be, since the effects of these appear in the temperature difference. The value o˘ this was determined for canvas covered surfaces, and a complete explanation of its significance is given.

While a careful study of conditions is necessary before a certain type of covering can be recommended for a certain type of work, the author hopes the data given in the paper will be of use to engineers in deciding upon covering material and in calculating heat losses in installations already in use.

CIRCULATION IN HORIZONTAL WATER TUBE BOILERS

By Paul A. Bancel, jun. am. soc. m. e.

Flowing within a boiler under steam are two fluids, steam and water, and these have different velocities, the steam being said to "slip" through the water.

By considering the flow in a simple circuit, and citing experiments with the air iift, an example of such a circuit, the conditions favorable and otherwise to slip are revealed. These experiments indicate that slip and friction change the relation of volume to velocity to nearly the square root law.

In an actual water tube boiler, with the circuit more complex, it is shown that with the bottom tubes discharging a light weight mixture and with slip and eddies due to the large area of the header and resistance due to the restricted area and abrupt turn at the entrance to the drum, there is a choking of circulation, particularly in the bottom tubes where it is most needed.

Constructions with circulation flues in the front header as means of improving circulation are shown.

Photographs illustrating the circulation, both front and rear, in the header of a model boiler with glass cover plates and with different types of headers and relative positions of boiler, fire and gas passages, show strikingly the conditions obtaining at loads up to 500 per cent.

UNIQUE HYDRAULIC POWER PLANT AT THE HENRY FORD FARMS

By Mark A. Replogle, mem. am. soc. m. e.

The hydraulic power plant recently constructed at the Henry Ford Farms contains two turbines designed to develop 85 h.p. each under 8 ft. head at 110 r.p.m., with electric generators. Current is supplied for light, heat and power for the residence, the village pumping station, and for the miscellaneous requirements of the farms.

There were unusual flowage conditions due in part to high water at certain periods and in part to back water from the Great Lakes. These conditions were met, and a uniform delivery of power secured, through the adoption of unusual features in the installation of the turbines. These features in the main consist of so-called turbine discharge accelerators built into the tailrace of each turbine, whereby an added head-effect is produced and the flow through the turbine increased. The accelerator consists of a form of draft tube into which the turbine discharges and into which, also, water from the upper level is discharged through a feeder terminating in an annular ring surrounding the outlet of the

discharge tube from the turbine. The water from the feeder increases the flow—accentuates the flow through the draft tube. Experiments conducted at this plant indicate: (1) That the turbines can be speeded for full head at low water conditions; (2) that if water is available, the power capacity of the turbine can be practically doubled at the same head; (2) that if water is available the unit can develop its normal rated power at one-half head; (4) that considerable power can be furnished at normal speed when the working head is less than 25 per cent of the normal head. All of this may be accomplished at good efficiency.

THE FLOW OF AIR THROUGH THIN-PLATE ORIFICES

BY ERNEST O. HICKSTEIN, JUN. AM. SOC. M. E.

This paper describes in some detail the methods used by a large pipe-line company in the Mid-Continental field in the calibrating of its orifice meter discs.

An orifice meter consists of a calibrated disc in a pipe-line, with pressure line connections running to two indicating or recording gages; one gage is for measuring the static pressure of the flowing gas and the second the differential drop of pressure across the orifice disc.

The paper deduces the following general formula for the flow of air through an orifice disc:

$$Q_o = C_g\sqrt{hP_1}$$

where

Q_o = volume at standard temperature and pressure
C_g = so-called "gas constant," found experimentally
h = differential in in. of water
P_1 = pressure at inlet of orifice

It then describes in detail tests made on orifice meters at Joplin, Mo., to determine the velocity coefficients of 8 and 10-in. orifice meters. The discs were calibrated against the displacement of air from an old artificial gas holder, with lower lift capacity of 110,000 cu. ft. Preliminary tests were run to determine leakage from the holder and changes of volume in holder with temperature variation.

About 160 tests were then run on 8 and 10-in. meters; a summary of the results is given in the paper.

Nearly fifty orifice meters have been installed and are now in operation, their deliveries of high pressure gas being calculated from the air constants found in the Joplin tests. It is confidently expected that, with some little further study and experimenting, the orifice meter will take its place among the most reliable methods of measuring natural gas in large quantities.

ELASTICITY AND STRENGTH OF STONEWARE AND PORCELAIN

BY JAMES E. BOYD

This investigation was undertaken at the suggestion of Ralph D. Mershon, Mem. Am. Soc. M. E., who expressed the belief that exact knowledge of the form of the stress-strain diagrams of clay products in tension and compression would make possible the design of insulators of greater mechanical strength and more definite factor of safety.

The pieces tested were porcelain pieces from the General Electric Co., stoneware pieces from the Keasbey Stoneware Works and also some porcelain pieces made in the Department of Ceramics of the Ohio State University.

All measurements of deformation were made by means of a lever extenso-meter, a Brown and Sharpe micrometer being used to measure the movement of the longer arm.

A form of grip was developed which eliminates the eccentricity of loading of the best pieces due to lack of perfect symmetry in the heads of the pieces. With all grips, however, it was found that the test pieces broke at the head, so the form of the pieces was modified.

The results of the tests indicate that the modulus of elasticity of stoneware and porcelain is practically the same in tension as in compression. The modulus of elasticity of porcelain is about 10,000,000 while that of stoneware ranges from 6,000,000 to 9,000,000, depending on the material. The compressive strength of porcelain and high stoneware in a column 16 in. long and 1 in. in diameter is about 20,000 lb. per sq. in. The stress-strain diagram is practically straight up to 7000 lb. per sq. in. The tensile strength of porcelain is above 3000 lb. per sq. in. The tensile strength of stoneware ranges from above 1100 to above 2200 lb. per sq. in.

FOUNDATIONS

BY CHAS. T. MAIN, MEM. AM. SOC. M. E.

It is of great importance to support all structures on a stratum of soil below silt or peat. If the structure is to be a heavy one, it is necessary to use piles. Buildings which are to contain moving machinery or delicate instruments would naturally require piles with fairly large factors of safety.

Soils are tested as to their suitability for foundations by making wash borings. Test pits furnish an opportunity of observing the character of the soil. If the structure is to be a heavy one, some of the borings should be carried to bed rock and dry samples of the soil taken every few feet.

Work on foundations consists of excavation of earth or rock, including shoring, sheet piling, or coffer dams, and a structure of stone, concrete, brick or timber at the bottom of the excavation, including bearing piles.

Where the depth of good bottom is too great to be reached economically by the foundations, it becomes necessary to use piles, the values of the factor of safety and working or ultimate strength of which are all to be fixed to suit the class of structure to be supported.

The structures most commonly used at the bottom of the excavation are concrete, stone laid in cement mortar or bedded rock, stone laid with outside joints pointed and then grouted full, and stones laid dry.

OIL ENGINE VAPORIZER PROPORTIONS

BY LOUIS ILLMER, MEM. AM. SOC. M. E.

This paper is the synopsis of a research made some time ago to determine the proper proportions of hot bulbs for oil engines of the Hornsby-Akroyd type, and largely extended of late to include high compression oil engine vaporizers.

The vaporizer of low compression oil engines is heated by the gases of combustion and provides a hot surface for the double purpose of evaporating the heavy mineral oils in the fuel-oil and of maintaining the confined mixture charge at a temperature high enough to enable self-ignition to be induced.

The one simple relation suitable for design purposes is that of vaporizer volume to piston displacement. The other design factors depend upon more involved relations and cen-

ter about the average temperature attained by the unjacketed cap portion of the vaporizer wall. By analysis, the average full load cap temperature of a Hornsby-Akroyd engine is found to be about 1275 deg. fahr. The total vaporizer volume should be about 0.3 of the piston displacement or about 2/3 the clearance volume.

When a Hornsby-Akroyd engine is running on 1/3 to ½ of the full load oil, the hot products of combustion may be expected to raise the temperature of the entire vaporizer content to 750 deg. fahr. ignition temperature. Below this critical point, the temperature head is reduced to such an extent that the cap no longer keeps the vaporizer content sufficiently preheated to reach the ignition temperature at the end of the compression temperature. The limit of efficiency and m.e.p. of the engine are so restricted as to make it quite cumbersome in sizes of 50 b.h.p. and upward. This limitation may be overcome by injecting the fuel-oil, by means of highly compressed air, near the end of the compression stroke.

High compression oil engines operating at less than 135 lb. per sq. in. compression pressure should have their vaporizer volume made equal to the entire clearance space, while in high compression engines the vaporizer volume may be made proportionally smaller; at about 400 lb. compression the vaporizer may be dispensed with. The moderate preheating requirements of the high compression engine allow self-ignition to be attained without maintaining the vaporizer cap at full red heat; this reduces internal strains in the cap casting.

COUNCIL NOTES

At the meeting of the Council on October 8, 1915, it was voted to approve the following recommendations with regard to the Society's publications, as made by the Publication Committee:

Transactions

(1) That the publication of the annual volume of Transactions be continued.

(2) That it be published in the same size and binding as heretofore.

(3) That it shall contain subject to the approval of the Publication Committee, all of the papers and discussions presented at regular meetings of the Society (not including section meetings), and technical reports of Committees; and shall contain a syllabus of each paper, summarizing the essential facts and conclusions.

(4) That it shall contain all the papers and discussions presented at section meetings which in the opinion of the Publication Committee are of sufficient merit.

Revises

(1) That additional revised copies of the papers and discussion be printed and bound in pamphlet form at the earliest practicable date.

A charge will be made for such pamphlets.

Advance Papers

(1) That papers for the meetings of the Society be printed in pamphlet form in advance as heretofore, and be sent to members gratis upon request, a notice of these papers with syllabi being printed in The Journal one month before meetings.

The Journal

(1) That The Journal be published monthly as heretofore, but with the view of making it a semi-monthly or a weekly as soon as the amount of matter to be handled requires it and funds for that purpose are available.

(2) That the size of The Journal shall for the present remain as it now is.

(3) That The Journal shall contain:

(a) All of the papers and discussions presented at regular meetings of the Society, preferably in substantially complete form, or adequately abstracted, according to the character of the paper, as soon after the meetings as possible.

(b) Papers, or abstracts, with discussion, presented at meetings of Local Sections.

(c) Announcements and reports upon Society affairs and incidents, employment bulletin, library notes, personal notes, etc.

(d) Department for contributed discussions on papers previously published, or new matter.

(e) Members correspondence department, including suggestions on Society affairs.

(f) Review of world's technical press.

(g) Review of technical books, by experts selected by the Committee.

The Committee adopt as a policy that the Editor shall coöperate with the author to present all papers and discussions as concisely as possible, consistent with clearness and completeness. This not only adds to the utility of the paper, but will make possible the publication of more papers in complete form. An abstract should be done by the author. The Editor will coöperate towards securing uniformity.

The paper, "Flow of Air Through Thin Plate Orifices," by Ernest O. Hickstein, Jun. Am. Soc. M. E., was approved for the Junior Prize.

No award of the Student Prize was made this year.

W. L. R. Emmet and Spencer Miller were reported elected as the representatives of the Society on the Naval Consulting Board. The appointment by the President of W. R. Dunn to represent the Society at the inauguration of John Henry MacCracken as President of Lafayette College was reported. Wm. H. Wiley was appointed delegate of the Society to the convention of the Atlantic Deeper Waterways Association.

The Boiler Code Committee was empowered to make rulings where inquiries are made respecting constructions not covered by the Code, and to interpret any parts of the Code, but the action on all rulings made by the Committee was ordered reported to the Council for approval before being issued.

The appointment as a Committee on Sections in Los Angeles of W. W. Smith, *Chairman*, W. A. E. Noble, *Vice-Chairman*, Ford W. Harris, *Secretary*, O. J. Root and Frederick C. Finkle was approved. Leigh Hunt was appointed on the Increase of Membership Committee, in place of H. Struckmann, resigned.

The substitution of a Smoker for the usual Wednesday evening address at the Annual Meeting was authorized.

CALVIN W. RICE, *Secretary.*

REPORT OF THE NOMINATING COMMITTEE

As previously announced in The Journal, the Nominating Committee has reported the following names as candidates for the offices indicated:

For President:

D. S. JACOBUS, New York

For Vice-Presidents:

WM. B. JACKSON, Chicago, Ill.
J. SELLERS BANCROFT, Philadelphia, Pa.
JULIAN KENNEDY, Pittsburgh, Pa.

For Managers:

John H. Barr, New York
John A. Stevens, Lowell, Mass.
H. de B. Parsons, New York

For Treasurer:

Wm. H. Wiley, New York

CONFERENCE OF LOCAL SECTIONS AT THE ANNUAL MEETING

The great success attending the Conference of Local Sections at the Spring Meeting has prompted the Committee on Sections to arrange for such meetings of Section representatives to be one of the regular features at the Annual or Spring Meetings. Many items of considerable importance were developed at the last Spring Meeting and delegates were present from San Francisco, Atlanta, Milwaukee, Chicago, New York, Providence, Philadelphia, Cleveland, Worcester, Birmingham, etc. All Sections were not represented however, and it has been arranged therefore to pay the traveling expenses of an officer of every Section in the United States.

Preferably the delegate should be the Chairman or Secretary, if either of them may find it possible to attend, or the member of the local committee conversant with its activities. By this action it is hoped to have every Section represented by a delegate who can officially and comprehensively present the views and requirements of the members in their locality.

Invitations have been extended to several centers where no Section now exists to authorize some member to participate at the Conference with a view to establishing a Section.

It is hoped by this means to develop thoroughly and put on an efficient basis this very important phase of the Society's activities. Information may be obtained by addressing any member of the Committee on Sections.

Elliott H. Whitlock, *Chairman,* 1506 West 112th St., Cleveland, Ohio
W. F. M. Goss, Univ. of Illinois, Urbana, Ill.
L. C. Marburg, 1790 Broadway, New York, N. Y.
Walter Rautenstrauch, Columbia Univ., New York, N. Y.
D. Robert Yarnall, Chestnut Hill, Philadelphia, Pa.

STUDENT BRANCH CONFERENCE

Representatives of various Student Branches of the Society held a meeting at the last Annual Meeting and so much benefit was derived by those who attended that it was voted to make the Student Branch Conference one of the regular features of the Annual Meeting.

Invitations have been issued therefore to all Student Branches to appoint delegates to the Conference at the coming Annual Meeting. Some of the colleges are at such a great distance that it will probably be impossible for the Student Branch to send an undergraduate representative. It is hoped that those Branches who cannot send an undergraduate will arrange for a graduate or one of the faculty to represent them.

Medallion Presented by the Panama-Pacific International Exposition to The American Society of Mechanical Engineers, September 16, 1915

CORRECTION

LABORATORY FOR LIQUID METERS

In a letter dated September 28, Geo. H. Gibson points out an error in his discussion of the paper on Laboratory for Liquid Flow Meters by W. S. Giele, published in Vol. 36 of Transactions, page 757. In place of the first paragraph of his discussion, the following paragraph should be substituted:

It is ordinarily assumed that the flow over a V-notch weir increases as the 5/2 power of the head, that is according to the formula $F = CH^{5/2}$ This assumption possibly simplifies calculations and in the absence of facilities for testing V-notch weirs under all conditions and heads, manufacturers of flow recorders for use with such weirs have used it in the laying out of the cams of the recorders, by means of which the rise of the float measuring the head on the weir is translated into the motion of the pen recording the flow.

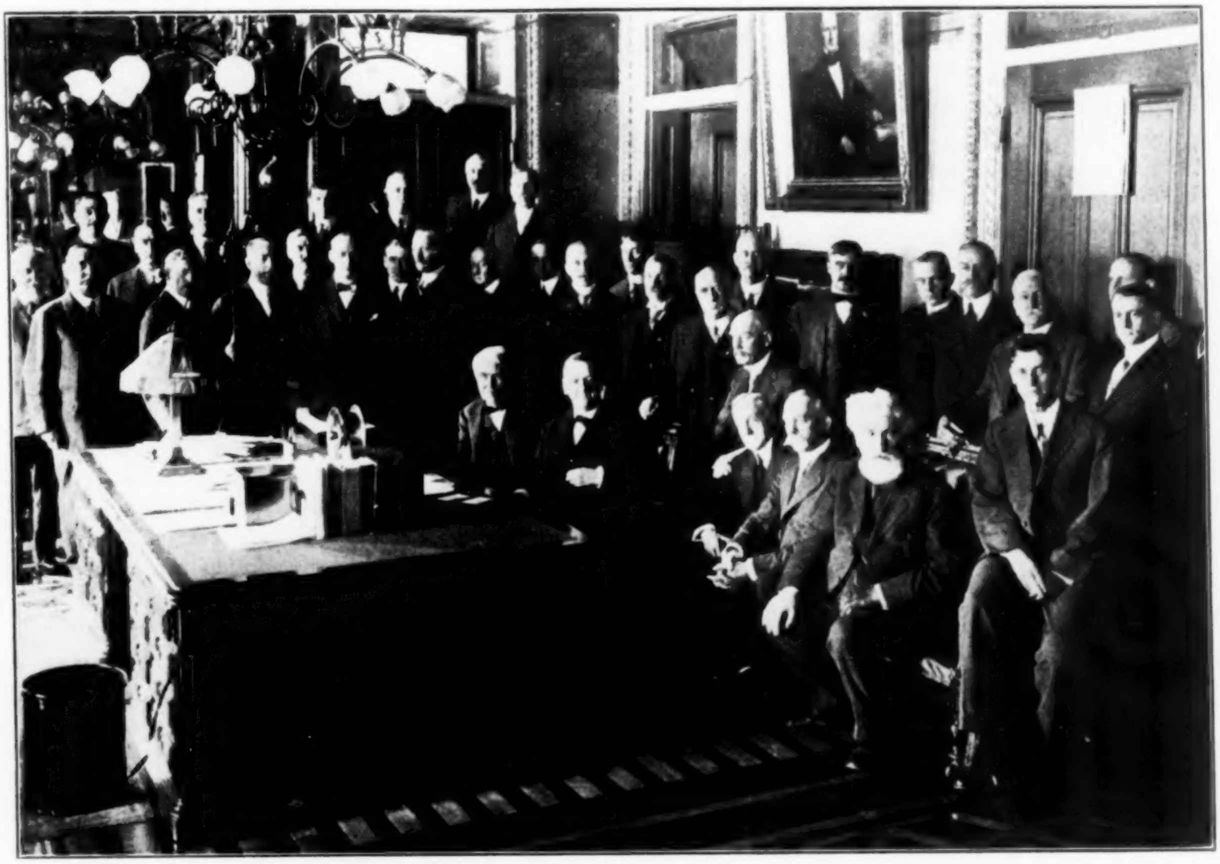
NEW EDITION OF THE BOILER CODE

A second edition of the Boiler Code which contains a comprehensive index to the volume has been issued. The index is divided into two parts, one a general index to the complete rules and the other containing sectional indexes to the parts referring to New Installations of Power Boilers, New Installations of Heating Boilers, and Existing Installations.

NAVAL ADVISORY COUNCIL AND NAVAL CONSULTING BOARD

The historic photograph on this page was taken at the first meeting of the Naval Advisory Council and the civilian Naval Consulting Board at Washington on October 6, 1915. This is the first time that civilians, representing the public through the national engineering societies, have been called into convention with officers of the Government to discuss problems of the Navy. The photograph shows the Secretary of the Navy, Hon. Josephus Daniels, seated beside Thomas A. Edison, and the departmental associates of the former in convention with the country's distinguished and leading civilian inventors and engineers.

The members of the Naval Advisory Council are practically all chiefs of departments; they welcomed the formation and organization of the civilian Board, the latter to constitute a non-partisan research body to assist in passing upon inventions and ideas submitted to the Navy.



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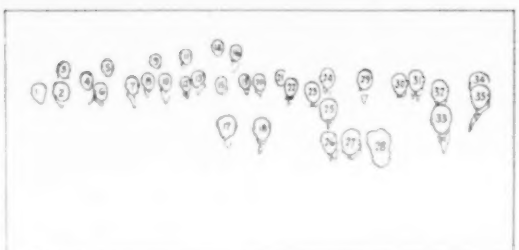


1. Rear Adm. Robert S. Griffin (n).
2. Benjamin G. Lamme (c).
3. Rear Adm. Victor Blue (n).
4. Rear Adm. David W. Taylor (n).
5. Spencer Miller (c).
6. Frank J. Sprague (c).
7. Henry A. W. Wood (c).
8. Lawrence Addicks (c).
9. Capt. Ridley McLean (n).
10. Howard E. Coffin (c).
11. Rear Adm. Joseph Strauss (n).
12. Thomas Robins (c).
13. Wm. Leroy Emmet (c).
14. L. H. Baekeland (c).
15. W. L. Saunders (c).
16. Maj. Gen. George Barnett (n).
17. Thomas A. Edison (c).
18. Hon. Josephus Daniels (n).
19. W. R. Whitney (c).
20. Peter C. Hewitt (c).
21. Rear Adm. H. R. Stanford (n).
22. Joseph W. Richards (c).
23. Alfred Craven (c).
24. Benjamin B. Thayer (c).
25. Andrew M. Hunt (c).
26. Elmer A. Sperry (c).
27. Arthur G. Webster (c).
28. Hudson Maxim (c).
29. Andrew L. Riker (c).
30. Surg. Gen. Wm. C. Braisted (n).
31. Rear Adm. Wm. S. Benson (n).
32. Robert S. Woodward (c).
33. Mathew B. Sellers (c).
34. Paym. Gen. Samuel McGowan (n).
35. M. R. Hutchinson.

(n) = Naval Advisory Council.
(c) = Civilian Naval Consulting Board.

FIRST MEETING OF NAVAL ADVISORY COUNCIL AND CIVILIAN NAVAL CONSULTING BOARD, WASHINGTON, OCTOBER 6, 1915

At the first meeting of the joint Boards, Thomas A. Edison was elected Chairman of the civilian Board; Peter Cooper Hewitt, First Vice-Chairman; William L. Saunders, Second Vice-Chairman; and Thomas Robins, Secretary. The entire civilian Board is being resolved into committees.

Secretary Daniels appointed Rear Admirals Taylor, Strauss and Griffin as a Committee on Inventions in the Navy Department, and this committee is to appoint an officer to receive all suggestions from in-

ventors. Promising inventions will be forwarded by this committee to each member of the civilian Board, and each is expected to express an opinion respecting the feasibility of the invention or to mark it "no report." The Boards recommended a plan to establish a research laboratory to cost eventually $5,000,000, and the Secretary of the Navy will ask Congress for an appropriation of $1,000,000 to begin work. The essentials of the plan for this laboratory in which it is proposed to submit to actual test all seemingly meritorious naval inventions are as follows:

1. The laboratory to be located on tidewater of sufficient depth to permit a dreadnought to come to the dock; near but not in a large city, so supplies may be easily obtained and where labor is obtainable.
2. The laboratory to be of complete equipment, to enable working models to be made and tested to destruction. There should be: A pattern shop; a brass foundry; a cast iron and cast steel foundry; machine shops for large and small work; sheet metal shop; forge shop for small and large work; marine railway large enough to build experimental submarines of 1,500 tons; woodworking shops; chemical laboratory; physical laboratory; optical grinding department, &c.; motion picture developing and printing department; complete drafting rooms; electrical laboratory and wireless laboratory; mechanical laboratory and testing machines; explosives laboratory, removed from main laboratory.
3. The building to be of modern concrete construction, with metal sills and doors, wire glass windows, ample fire protection, &c.
4. A naval officer of rank to be in charge. Under him naval heads of broad experience in laboratory methods and science in general—practical as well as theoretical men. Under them staffs of civilian experimenters, chemists, physicists, &c. Each subhead to have his corps of assistants, and shop facilities. There is to be at least two, and possibly three shifts of men.
5. Secrecy to be the governing factor.
6. Facilities to exist for enabling the inventor to assist in the development of the idea he has presented, provided he is a practical man.

The next meeting of the Boards will take place on November 4 in New York City.

MEMORIAL SERVICE TO PAST-PRESIDENT FREDERICK WINSLOW TAYLOR

A remarkable service was held in Philadelphia Friday evening, October 22nd, in Houston Hall of University of Philadelphia, under the auspices of the Society to Promote the Science of Management. The hall was filled to overflowing with many of the leaders in management, representatives of Philadelphia's citizens and the following official participants in the meeting:

The provost of the University, Edgar Fahs Smith; the Mayor of Philadelphia, Rudolph Blankenburg; President of the Society to Promote the Science of Management, Dr. Harlow S. Person; Louis D. Brandeis; Past-President of this Society, James M. Dodge; three former associates of Mr. Taylor, all members of this Society, H. L. Gantt, Carl G. Barth and Sanford E. Thompson; and Colonel Vignal, military attaché at the French Embassy, who read a letter from Henri Le Chatelier. A full account of these addresses will be presented to the Society at the annual meeting in December by a Committee that represented the Society at the exercises, consisting of Henry R. Towne, F. R. Hutton, John R. Freeman and Oberlin Smith.

On Saturday the party met at Boxley, near Highland Station, Philadelphia, the former home of Mr. Taylor and was shown about the house and grounds.

ENDORSEMENT OF THE BOILER CODE BY THE NATIONAL ELECTRIC LIGHT ASSOCIATION

An important coöperative movement in the introduction of the Boiler Code into legislative channels in the various states, is the recognition given at a recent meeting of the National Electric Light Association in approving the action of the American Uniform Boiler Law Society in its work of securing the general adoption of the Boiler Code recently formulated by a Committee of The American Society of Mechanical Engineers. The National Electric Light Association has appointed John Hunter, member of the Council of the Am. Soc. M. E., as its representative to serve on the executive committee of the American Uniform Boiler Law Society, who is expected to be particularly able in securing the coöperation of member companies of the National Electric Light Association in any state where the adoption of the Code is being agitated.

COLLEGE REUNION NIGHT AT THE ANNUAL MEETING

During the last few years a very pleasing arrangement has been made whereby those attending the Annual Meeting who are graduates of one of the technical colleges have enjoyed a reunion of their Alumni Association. This year College Reunion Night will occur on Friday, December 10, and arrangements are under way for reunions of alumni of the following colleges: Brown University, Cornell University, Massachusetts Institute of Technology, Polytechnic Institute of Brooklyn, Purdue University, Rensselaer Polytechnic Institute, State University of Kentucky, Stevens Institute of Technology, Worcester Polytechnic Institute and Yale University.

The Society will be pleased to place at the disposal of any college alumni organization the facilities of the office or publications to develop reunions in connection with the coming Annual Meeting, and such organizations are invited to correspond with the Secretary. The large number of engineering graduates visiting New York at that time of the year offers an excellent opportunity for successful reunions.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON DECEMBER 1, 1915

Members are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their ages would qualify them and not with regard to professional qualifications, i. e., the ages of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote. The candidates will be balloted upon by the Council unless objection is received by December 1, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Aeberli, J. Adolf, Ch. Hyd. Engr., Canadian Allis-Chalmers Ltd., Toronto, Canada

Arnaiz, Walter P., Ch. Draftsman, The Amer. Pulley Co., Philadelphia, Pa.

Barnes, Frederick A., Mech. Engr., Geo. S. Riderand Co., Cleveland, Ohio

Britton, William M., Elec. and Mech. Engr., Q. M. Corps, U. S. Army, Washington, D. C.

Brotherhood, Rowland S., Asst. Engr., Internatl. Silver Co., Meriden, Conn.

Campbell, Edmund D., Asst. Ch. Estimator, Passenger Car Dept., Amer. Car & Fdy. Co., St. Louis, Mo.

Carlson, John A., Indus. Engr., Remington Typewriter Wks., Ilion, N. Y.

Deulinger, Benjamin G., Mech. Foreman, Astoria Light, Heat & Pwr. Co., Astoria, L. I., N. Y.

Edwards, Oliver C., Instr. in Mech. Engrg., Univ. of Minn., Minneapolis, Minn.

Ferrari, Carl, Mech. Engr., Erie City Iron Wks., Erie, Pa.

Gifford, George B., Mgr. Bayonne Wks., Standard Oil Co., Bayonne, N. J.

Kennedy, William J., Ch. Engr., Genl. Dept., Boston Edison Co., Boston, Mass.

McAdam, John V., Pres., Revolute Mch. Co., New York.

McLean, Donald M., Mech. Engr. and Designer, Dover Boiler Wks., Dover, N. J.

Mabey, Arthur R., Foreman Thermometer Dept., Bristol Co., Waterbury, Conn.

Mistele, Henry J., Ch. Engr., Pwr. Dept., The Falk Co., Milwaukee, Wis.

Moul, Harry A., Cons., Contr., and Efficiency Engr., Philadelphia, Pa.

Nyrop, Michael J. F., Mech. Engr., General Elec. Co., Lynn, Mass.

Otis, Robert B., Directing Engr. in charge of Dept. of Engrg., Central Continuation Schools of Milwaukee, Milwaukee, Wis.

Peters, Heber C., Dist. Mgr., The Adder Mch. Co., Wilkes-Barre, Pa.

Proctor, Alfred W., Cons. Mech. Engr., New York

Rawson, William B., Safety Engr., Canada Cement Co., Ltd., Montreal, Can.

Ray, Edmund S., Ch. Engr., Francisco Sugar Co., Francisco, Camaguey Prov., Cuba.

Street, George L., Jr., Vice-Pres., J. R. Johnson & Co., Inc., Richmond, Va.

Thompson, James A., Mech. Supt., Brandram Henderson, Ltd., Montreal, Can.

Thomson, Samuel G., Supt. Motive Pwr. and Rolling Equipment, Penn. & Reading Rwy., Reading, Pa.

Weschler, George A., Assoc. Prof. Mech. Engrg. in Charge of Dept., The Catholic Univ. of Amer., Washington, D. C.

Westcott, Harry R., Supt. of Constr., The United Ill. Co., New Haven, Conn.

White, Louis E., Treasurer, Gale Mfg. Co., Albion, Mich.

Winge, Otto C., Specl. Designer with New Era Mfg. Co., New York

Wood, Fred L., Supt., Aeolian Co., Meriden, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

Bergstrom, Harry E., Round House Work Foreman, Nor. Pacific Rwy., Duluth, Minn.

Binckes, Frederick J., Instr. Mech. Drawing and Mech. Design, The Central Tech. School, Toronto, Canada

Bowles, John D., Elec. Supt., Springfield Gas & Elec. Co., and Springfield Traction Co., Springfield, Mo.

Callahan, Thomas E., Genl. Foreman, Bearing Dept., Doehler Die Casting Co., Brooklyn, N. Y.

Carver, Fred S., Cons. Engr., Newark, N. J.

Cuervo, Manuel V., Mem. of Firm, Cuervo & Pagliery, Cons. Engrs., and Dealers in Mchy., Havana, Cuba.

Estrada, Rafael, Jr., Asst. Engr., United Gas & Elec. Corp., New York.

Ford, Everett L., Factory Supt., Frank Mossberg Co., Attleboro, Mass.

Gladeck, Frederick C., Ballistic Engr., American Ammunition Co., Inc., New York.

Gould, Merle E., with Hyatt Roller Bearing Co., Harrison, N. J.

Hutchinson, John A., Engr., Internatl. Silver Co., Meriden, Conn.

Jellum, Kristen, Designing Engr., Winslow Safety High Pressure Boiler Co., Chicago, Ill.

Johnstone, Edward J., Chem. Engr. for Prof. F. M. Williams, Cons. Chem. Engr., Watertown, N. Y.

Pirie, Hugh L., Insptr. of Ordnance Mchy., in charge of No. 1 Traveling Workshop, British War Office, 1st Corps B. E. F., France.

FOR CONSIDERATION AS JUNIOR

Austin, Richard S., Asst. Mech. Engr., Cott-a-lap Co., Somerville, N. J.

Ballou, John M., Draftsman, The Babcock & Wilcox Co., Bayonne, N. J.

Bickley, Creighton D., Ordnance Insptr., Projectile Dept., Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa.

Bolton, John W., Jr., Mech. Engr., Eagle Knife & Bar Co., Lawrence, Mass.

Bower, Robert S., Mech. Dept., The River Furnace Co., Cleveland, Ohio

Briggs, Hermon B., Instr. in Mech. Drawing, The North Carolina College of Agri. and Mech. Arts, W. Raleigh, N. C.

Chew, John J. 2nd., with Remington Arms & Ammunition Co., Bridgeport, Conn.

Conard, Frederick U., Asst. Foreman, Fast Warp Dept., Jennings Lace Wks., Brooklyn, N. Y.

Cornwell, Eugene W. K., Engr., Keystone Forging Co., Northumberland, Pa.

Dabney, John C., Jr., Supt., Glamorgan Pipe & Fdy. Co., Lynchburg, Va.

Danforth, Thomas D., Mech. Engr., U. S. Radiator Corp., W. Newton, Pa.

Davis, John R., Asst. Foreman of Sacking Room and Warehouse, United States Gypsum Co., Oakfield, N. Y.

Fales, Dean A., Grad. Mass. Inst. Tech., 1915, West Newton, Mass.

Fletcher, Harold W., Engr., Newark Spring Mattress Co., Newark, N. J.

Flohr, Ralph C., Efficiency Engr., The Amer. Tool Works Co., Cincinnati, Ohio.

Foley, Louis J., Tech. Statistician, Pierce-Arrow Motor Car Co., Buffalo, N. Y.

Greenman, Philip R., Valve Developing Engr., Detroit Lubricator Co., Detroit, Mich.

Hess, Alexander M., Automatic Mchy. Designer, E. Kramer Mch. Co., Carlstadt, N. J.

Iler, William T., Jr., Student Apprentice, H. W. Johns-Manville, Manville, N. J.

Ingersoll, Howard H., with The Atlantic Refining Co., Providence, R. I.

James, Richard M., Rate Setter, Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

Kemp, Henry D., Formerly Asst. Mgr. Foreign Dept., Mead-Morrison Mfg. Co., East Boston, Mass.

Lytle, Charles W., Co-ordinator and Instr., Mechanics Institute, Rochester, N. Y.

McKinney, William P., Machine Shop, Marion Steam Shovel Co., Marion, Ohio

McNeal, Daniel R., Turbine Engrg., Westinghouse Mch. Co., E. Pittsburgh, Pa.

Magee, John F., Engr., Alpha Portland Cement Co., Easton, Pa.

Matson, John J., Research, Leland Stanford Junior Univ., Cal.

Newby, Howard L., Ch. Draftsman, Ft. W. & D. C. R.R. Co., Childress, Tex.

Newman, Harry P., Asst. Foreman, Remington Arms & Ammunition Co., Bridgeport, Conn.

Porter, David B., Investigator, David Maydole Hammer Co., Norwich, N. Y.

Rebman, Charles G., Asst. Engr., Hess Bros., Inc., New York

Reckendorfer, John K., 2nd Asst. to Vice-Pres., Amer. Lead Pencil Co., Hoboken, N. J.

Sharkey, William E., Asst. to Ch. Engr., The Miami Cycle & Mfg. Co., Middletown, Ohio.

Smith, Edwin R., Rep. Fitchburg Mch. Works, Fitchburg, Mass.

Williams, Edward H., Grad. 1915, Mass. Inst. Tech., Boston, Mass.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Selser, Thomas W., Mech. Engr., Inter-state Commerce Comm. of U. S. Govt., San Francisco, Cal.

PROMOTION FROM JUNIOR

Bixby, William P., Constr. Engr., Public Service Elec. Co., Newark, N. J.

Crowell, William J. Jr., Ch. Chemist, Amer. Iron & Steel Mfg. Co., Lebanon, Pa.

Cushman, Frank Jr., Head of Dept. of Mech. Arts and Applied Science, Kansas City Polytechnic Inst., Kansas City, Mo.

Davis, Edwin H., Engr. and Designer, American Steam Pump Co., Battle Creek, Mich.

Dirks, Henry B., Instr. in Engrg. Drawing and Mch. Design, Princeton Univ., Princeton, N. J.

Donaldson, Stuart A., Mech. Asst. to Operating Mgr., Equitable Office Bldg. Corp., New York

Erlenkotter, Walter, Fuel Engrg. Chemist, in charge of Central Testing Lab'y, Bureau of Contract Supervision, City of New York.

Fraser, D. Ross, Vice-Pres. and Supt., Chicago Portland Cement Co., Oglesby, Ill.

Gildehaus, Richard F., Jr., Supervising Engr., Busch Interests, Anheuser-Busch, of St. Louis, at Dallas, Tex.

Hazleton, Robert T., Supt. and Head of Engrg. Dept., Cincinnati Milling Mch. Co., Cincinnati, Ohio

Heidelberg, Frederick M., Mech. Engr., Copper Queen Cons. Mining Co., Bisbee, Ariz.

Hirschland, Franz H., Vice-Pres. and Genl. Mgr., Goldschmidt Detinning Co., New York.

Hobbs, James C., Asst. to Supt. of Pwr. Stations, Duquesne Light Co., Philadelphia, Pa.

Husted, Clifford M., Asst. Supt., Eagle Works, Standard Oil Co. of N. J., Claremont, Jersey City, N. J.

Lang, Charles, N. Y. Mgr., C. H. Wheeler Mfg. Co., New York

Miller, Richard E., Mech. Engr., The J. W. Frazier Co., Cons. Engrs., Cleveland, Ohio

Moyer, Allen V., Mech. Engr., The George T. Ladd Co., Pittsburgh, Pa.

Newell, William, Ch. Safety Engr., State Ins. Fund, New York

Peper, John H., Jr., Mech. Engr., New York Transit Co., New York.

Ricketts, Edwin B., Engr. of Tests, The New York Edison Co., New York.

Ruppel, Richard, Ch. Engr., J. Byers Holbrook, Cons. Engrs., New York

Schenck, Charles, Wks. Mgr. and Ch. Engr., Elevator Supply & Repair Co., Hoboken, N. J.

Schoenijahn, Robert P., Mech. and Elec. Engr., Wilmington & New Castle County Bldg. Comm., Wilmington, Del.

Sturgis, William B., Asst. Ch. Engr., in charge of Constr. Dept., Nichols Copper Co., Laurel Hill, L. I., N. Y.

Walker, Frank A., Engr., with B. B. and R. Knight, Providence, R. I.

Wood, Thomas C., United States Inspector, The Panama Canal, Chicago, Ill.

Wilson, Robert A., Mas. Mech., Producers Oil Co., Houston, Tex.

Whipple, William, Supt., Cinclare Central Factory, Cinclare, La.

SUMMARY

New applications	80
Applications for change of grading	29
Total	109

SAN FRANCISCO MEETING

THE two papers presented at the first session, September 16, of the September meeting of the Society held at San Francisco in connection with the Panama-Pacific International Exposition and the International Engineering Congress were published in the October issue of The Journal. The three remaining papers, by Prof. W. H. Adams; A. H. Goldingham and Prof. G. H. Marx and L. E. Cutter, presented at the second session, September 17, are published in this issue. The paper by Professor Adams outlines very completely Diesel engine design and tendencies and considers the operation of this type of engine with various fuels. Mr. Goldingham's paper embraces heavy oil engines, both of the Diesel and hot surface types, and includes new cost data. Professor Marx and Mr. Cutter's paper on gear teeth throws light upon the question of allowable stress for modern cut cast-iron gear teeth.

THE DIESEL ENGINE AND ITS APPLICATIONS IN SOUTHERN CALIFORNIA

BY WALTER H. ADAMS, PASADENA, CAL.

Member of the Society

DIESEL secured his first patents in 1893, and brought out his first successful engine in 1897, at the Augsburg Works in Germany, and since the latter date the use of the Diesel engine has been increasing steadily, especially in Europe. Several well-known steam engine manufacturers in the United States today have begun the manufacture of Diesel engines, thus showing a growing demand in this country for such a prime mover. There are comparatively few Diesel engines in the United States at present, the total horsepower in use being just over 100,000, but the number is increasing rapidly every month.

Diesel's original patent described the action of his engine as follows: (*a*) The highest temperature is that due to the compression of air only and this may be regulated by making the compression the desired amount. (*b*) Into this air is introduced the fuel, gradually, in a finely divided state and in such quantity that the burning offsets the cooling due to the expansion as the piston moves forward.

This was the original idea of Diesel, namely, a supply of heat at constant temperature. Such a supply would fulfil one of our thermodynamic conditions for maximum efficiency —a supply of heat at a constant maximum temperature. Diesel's engine in practice did not give this desired result, so he modified his statement to cover an increase in temperature during the admission of the fuel, this increase in temperature taking place at constant pressure. This is the condition of the Diesel engine today, as closely as it is possible for the actual engine to meet the ideal conditions.

The difference between the Diesel engine cycle and that of the standard form of internal combustion engine (Otto) is shown in Fig. 1. In the Otto cycle there is compression from *A* to *B;* ignition and burning at constant volume from *B* to *C;* expansion from *C* to *D;* and rejection of heat to the exhaust, at constant volume, from *D* to *A*. (It makes no difference in the ideal diagram whether the engine is 2- or 4-cycle.) In the Diesel engine there is corresponding compression from *A* to *B;* then burning at constant pressure from *B* to *C;* expansion from *C* to *D* and exhaust at constant volume from *D* to *A*. In the Otto cycle there is an explosion while the volume remains constant, thus increasing the pressure and temperature; in the Diesel cycle there is burning at constant pressure while the volume and temperature increase.

The expressions for the thermal efficiency of the ideal cycles are also shown in Fig. 1, and curves plotted from these equations are given in Fig. 2. The most interesting thing to observe from these curves is that, for corresponding pressures at the end of compression, the Diesel engine has the lower thermal efficiency. This is offset by the fact that in the Otto engine the limit of compression pressures is 80 to 200 lb. per sq. in., while in the Diesel engine the compression may be carried as high as desired. The reasons for this are that in the Otto engine the fuel is compressed with the air, and pre-ignition will take place if the compression is carried too high, due to increase of temperature with increase of pressure. In the Diesel engine, air only is compressed and the temperature may rise as high as desired without danger of pre-ignition. The temperatures due to compression are shown in Fig. 3. At a pressure of 500 to 550 lb. per sq. in. the temperature is about 1000 deg. fahr., and if fuel in a finely divided condition is introduced into air at this temperature, it will take fire and burn without any special ignition apparatus.

Fig. 3 was calculated for an adiabatic compression. There is considerable discussion as to what is the correct exponent for this curve as it varies with different engines; therefore the ideal curve is used. The actual temperatures would agree approximately, as the new charge of air is heated above 100 deg. fahr. by the hot cylinder walls and by mixing with the burnt gases in the clearance space. This makes a higher initial temperature although the compression curve is flatter than the ideal.

High compression is possible with the Diesel engine with corresponding gain in efficiency, and at the same time there is more complete combustion of the fuel because of the finely divided state in which it is forced into the cylinder. The maximum possible efficiency for the Otto engine is 52 per cent for blast furnace gas and 44 per cent for a motor car engine. Against this there is 57 per cent efficiency for the Diesel engine, a gain of 29 per cent over the motor car engine and 11 per cent over the blast furnace gas engine. If the Otto engine could have the same compression, it would be a better engine than the Diesel engine.

Presented at the Panama-Pacific International Exposition meeting, San Francisco, September 1915, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Contributed by the Los Angeles Section. The paper may be obtained in pamphlet form; price 10 cents to members, 20 cents to non-members.

This question may be asked: Why cannot the efficiency of the Diesel engine be further increased by higher compression than 500 to 550 lb. per sq. in.? This is possible in the ideal engine, but experience has shown that 600 lb. per sq. in. is the highest allowable pressure in the actual engine. For pressures above that amount, the increased size of the parts of the engine increases friction and cost above any gain in theoretical efficiency. Changes in the Diesel engine will have to be more along the line of reduced cost and simpler design rather than better economy.

2-CYCLE AND 4-CYCLE INTERNAL COMBUSTION ENGINES

The difference between the 2-cycle and 4-cycle types of internal combustion engine is in design and construction and not in theory.

In the 2-cycle engine there is expansion of the burnt gases until near the end of the stroke; then exhaust begins and almost simultaneously there is admission of either air and fuel or air alone at another part of the cylinder—this admission taking place under slight pressure. The burnt gases are forced out by the fresh charge, the piston moves back and compression takes place. This gives one working stroke for every revolution, just as in a single-acting steam engine. The necessary compression of the inlet air is supplied by the slight compression produced by the piston in an enclosed crank case (cheap engines), or is produced by a separate scavenging air compressor, as in all 2-cycle Diesel engines. In this type the pressure of the air is not carried to more than 4 to 8 lb. per sq. in. above atmospheric.

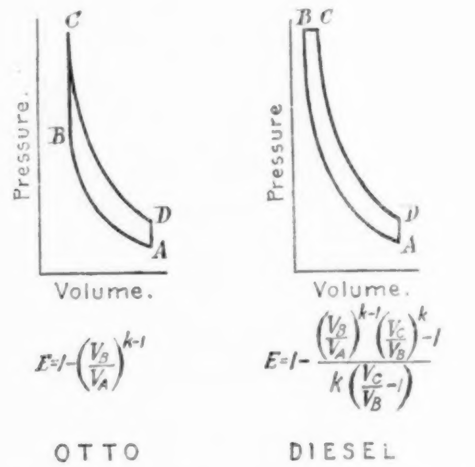


FIG. 1 COMPARISON OF CYCLES AND THERMAL EFFICIENCIES

In the 4-cycle type there are ignition and expansion until the end of the stroke. Then the exhaust valve opens and remains open until the piston has moved back, thus allowing the piston to expel the burnt gases. The exhaust valve closes and the admission valve opens, remaining open while the piston moves forward to draw in a fresh charge. It then closes and compression takes place. This complete cycle requires two revolutions of the engine and in practice necessitates a large flywheel or a multiple-cylinder engine if the speed is to be kept constant.

There are advantages and disadvantages for both types applied to Diesel engines. The 2-cycle type gives almost twice as much power for the same size of cylinder, as it has two working strokes for one in the 4-cycle. (Actual value is 170 to 180 per cent.) This means less weight, space and first cost. As usually constructed, the piston acts as its own valve and so air inlet and exhaust valves are not required. (This is not true of some of the better class of 2-cycle Diesel engines, as will be explained later.) In marine work the reduction in number of valves makes it easier to reverse a 2-cycle engine. The use of the 2-cycle type has also made large units possible, and 1200 h.p. per cylinder in a single-acting engine has been built.

On the other hand there is to be said for the 4-cycle type of Diesel engine:

a It is older than the 2-cycle type and so has become a more stable contruction

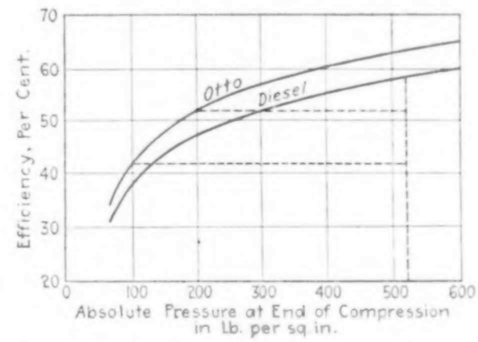


FIG. 2 COMPARISON OF EFFICIENCIES, OTTO AND DIESEL ENGINES

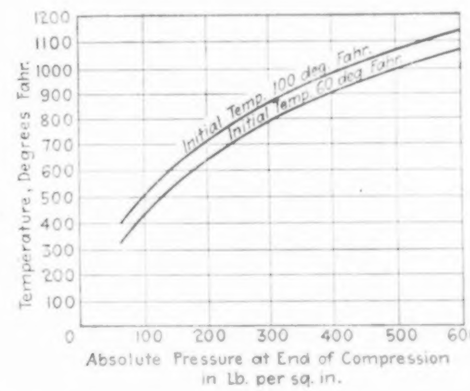


FIG. 3 DIESEL ENGINE COMPRESSION TEMPERATURES

b It gives better fuel economy, as expansion can be carried to the end of the stroke and no power is required for the scavenging pump. The gain is about 10 per cent

c The mean temperature is lower. There is more time to remove the heat and not so much heat to remove per unit of cylinder surface. (In a 2-cycle engine 90,000 B.t.u. per hour has to be removed for every square foot of cylinder surface. In 4-cycle engines the figure is 40,000 B.t.u. In an ordinary water-tube boiler working at 300 per cent of rating, it is 10,000 B.t.u.)

d The valve gear runs at one-half the speed of the main shaft

e In the high speed 2-cycle engine, it has been difficult to get the burnt gases out of the cylinder in the short time available, so that such engines have not been quite as successful as 4-cycle engines.

The tendency in this country and abroad is to use 4-cycle engines up to from 700 to 1000 h.p. and above that 2-cycle. This is due to the reduced first cost of the 2-cycle type in

the large sizes and the excessive diameter of cylinder required in large 4-cycle engines. As progress is made in design, the 2-cycle type may supersede the 4-cycle, but this is not evident at present in the smaller sizes.

APPLICATIONS OF THE DIESEL ENGINE

The Diesel engine is in use today in almost all places where a steam engine or turbine might be used. Its starting torque is poor and it should run at a constant speed, although this may be varied to some extent. The rated load decreases as the altitude at which the engine operates is increased.

The engine is being employed for propelling ships of over 400 ft. in length and 9000 tons in cargo capacity, at a speed ot about 11½ knots; such ships are twin-screw and have engines of 1600 b.h.p., developed in 6 cylinders. The engine has not been used for high speed passenger ships. It has been used in many sailing vessels to provide auxiliary power in calm weather. It has been used in submarines, and the Craig Shipbuilding Company is now building for the United States Government some submarines which are to be equipped with Busch-Sulzer Diesel engines.

One locomotive equipped with Diesel engines has been built in Europe, but it was large, clumsy and not very successful. Diesel locomotives will not compete with steam locomotives at present. For isolated plant or central station service the Diesel engine is well adapted, if several units are installed so that each unit will work near its rated load without a heavy overload under all conditions of load factor.

The Diesel engine gives excellent service when installed as a pumping engine. It can be used for all kinds of factory service just as well as the steam engine. The reasons why it is not adopted more extensively in this country are probably:

1 The availability of cheap fuel has prevented a demand for an expensive first cost prime mover that will give decreased operating cost
2 American manufacturers have been slow to take up the manufacture and introduction of these engines
3 Engines giving satisfactory service have only been made in Europe within the last five years
4 A Diesel engine requires extreme care in manufacture and in adjustment, particularly of the fuel valve
5 The engine cannot be operated without careful supervision when the cleaning and adjusting are going on
6 Some prejudice exists against all forms of internal combustion engines due to the multiplicity of causes that may prevent their starting
7 Oil must be used as fuel, and the cost may vary within wide limits
8 Innate conservativeness of the human race makes it slow to adopt a new method or machine until others have tried it.

DESIGN CHARACTERISTICS OF DIESEL ENGINES

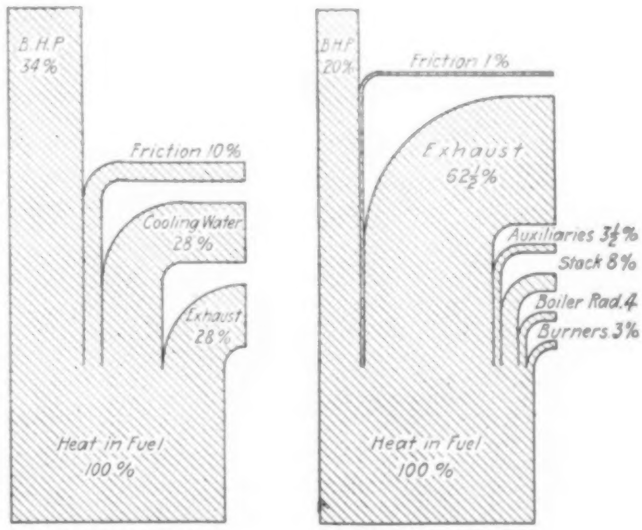
It is my intention to discuss design characteristics in a general way, summing up the present situation, rather than to describe details of the various types. (Since the preparation of this paper was commenced, an excellent article[1] on the design of the Diesel engine has been published in The Journal.)

[1] Vol. 36, December, 1911, page 420. Recent Developments in the Manufacture of the Diesel Engine, H. R. Setz.

At present, engines are manufactured in this country in both the horizontal and vertical types. One to four cylinders are used in the horizontal and one to six cylinders in the vertical engines. The favorite size of the latter is two to four cylinders.

The horsepower per cylinder ranges from 30 to 250, with size of cylinder varying from 12 to 21 in. The stroke bore ratio is about 1.25. (In December one manufacturer announced a 4-cylinder vertical engine of 2500 b.h.p.).

The smallest Diesel engine (dimensions of cylinder) that the author finds any record of is a 6¾ by 8⅝ in., 2-cycle, 4-cylinder engine, developing 110 b.h.p. at 550 r.p.m. The largest engine is a 32.2 by 39.4 in., 2-cycle, single-cylinder



4-Cycle Diesel Engine Plant. Large Steam Turbine Plant.

Fig. 4 Comparison of Heat Balances

engine, developing 1250 b.h.p. at 150 r.p.m., m.e.p. 106 lb. per sq. in. This latter is an experimental engine built by Carels Bros. in Belgium. If such an engine were built with 8 cylinders, it would have an output of 10,000 b.h.p., which would compare favorably with a steam turbine, if the space occupied be neglected.

The engines built in the United States are all comparatively slow speed, ranging from 150 to 300 r.p.m., with piston speed of 600 to 900 ft. per minute. A few high speed marine engines have speeds as high as 480 r.p.m. In Europe, before the war started, there was being developed a line of high speed engines with a speed of 550 r.p.m. for submarines and such work. The highest commercial speed in use at present is 350 to 400 r.p.m.

All engines, except one make, are single-acting. (One manufacturer reports the making of a double-acting engine, but I should judge that this has not been tried out thoroughly.) In Europe several firms were experimenting on a double-acting engine; the trouble experienced in this type is in cooling the cylinder and piston and keeping the stuffing boxes tight.

All engines in this country, except two makes, embody trunk pistons without crossheads. In Europe several marine

types use a crosshead, but all others employ the trunk piston. The crosshead takes the wear produced by the angular thrust of the connecting rod.

Valves and Valve Gear. There is necessarily considerable difference in the design of valves and gear of the 2-cycle and 4-cycle types. As the piston acts as its own valve in the high speed 2-cycle type, there are only two valves in the cylinder head—the fuel valve and air starting valve. In the better slow speed 2-cycle engines there are 7 valves in the cylinder head; these are 4 scavenging valves, 1 fuel valve,

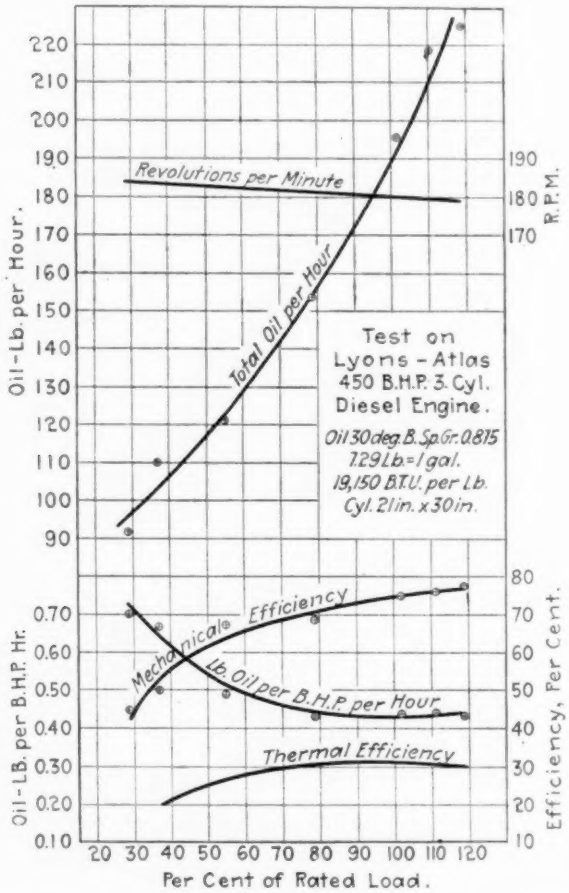


Fig. 5 Results of Tests on 3-Cyl. Lyons-Atlas Diesel Engine

1 starting air valve and 1 safety valve. (There are no American engines with 4 scavenging valves in the cylinder head.)

The 4-cycle engine must have at least 4 valves, namely, suction, exhaust, fuel and starting valves. The safety valve is often combined with the air starting valve. In most engines the valves are all placed in the head of the cylinder, but in a few types the suction and exhaust valves are placed on its circumference.

The material used for cylinder walls, liners, and heads is cast iron. A few engines have been equipped with cast steel heads, but these did not prove satisfactory and cast iron has been substituted.

Fuel Valve. The fuel valve in the Diesel engine is the most delicate part of it. Even when the engine is fully loaded, this valve moves only a few hundredths of an inch. In an engine with a 21 by 30 in. cylinder, the amount of oil per stroke at rated load is only 0.4 cu. in. When it is remembered that this oil must be introduced in the form of a very fine spray in a time of about 1/40 sec., and that the regulation of the amount of oil is the only method of governing the engine, it is easy to imagine the troubles of the early operators and designers. The fuel valve must not clog or fill with gum and must always operate correctly. The designs of the manufacturers vary in detail, but the underlying principle is the same. The fuel is pumped into a chamber surrounding the valve by a pump whose stroke is controlled by the governor; this chamber forms a labyrinth passage. Air under a pressure of 800 to 1000 lb. per sq. in. is admitted in back of the oil and forces the latter into the cylinder in the form of a fine spray. The valve is controlled by a cam, opening about 1 per cent before the end of the compression stroke and remaining open from about 8 to 10 per cent of the working stroke.

In most of the present engines, the oil is forced into the valve passages against the air pressure, thus requiring a strong oil pump. Several manufacturers have adopted the method of pumping the oil into a restricted passage between the air valve and the cylinder during the suction stroke of the engine, where it remains until the air valve opens and it is forced into the cylinder. This arrangement reduces the work of pumping. The relative merits of the two types are under discussion today. So far as the author can find out the low pressure type seems to give the best satisfaction with California oils. At least the manufacturers using this type say they can use any grade of oil, while the manufacturers of the high pressure type like to specify a minimum grade of oil that they can use.

The remainder of the design of the Diesel engine follows gas engine design quite closely, with generally more massive and careful construction. It is discussed more fully in the paper quoted above.

Air Compressor. The air used for spraying the oil into the cylinder is supplied by a 2- or 3-stage air compressor. The pressure required for the spray is 800 to 1100 lb. per sq. in., depending mainly upon the kind of oil used, but also to some extent on the load under which the engine is working. The amount of this air is estimated to be from 16 to 34 cu. ft. of free air per b.h.p. per hour. The power required for operating the compressor is about 4 to 7 per cent of the total power developed by the engine. The compressor is usually made an integral part of the engine, and is driven by a crank forged on the crank shaft. In a few cases it is driven by a belt from the engine or by a motor.

Scavenging Pump. In the 2-cycle engines a special scavenging pump is used for driving the burnt gases out of the cylinder. This is usually made the low pressure stage of the air compressor. As previously mentioned, the scavenging air is controlled by the piston or by scavenging valves in the cylinder head. This latter type gives the best scavenging, as the air sweeps through the cylinder from the head end, and passes out through ports placed around the circumference at the crank end. There is a large gain in economy and power due to using this scavenging air in the 2-cycle engine, because of better combustion, but it is not necessary in the 4-cycle engine.

The air is supplied at a pressure of 4 to 8 lb. per sq. in. above atmosphere. The volume of this air is from 1.2 to 1.8 times the cylinder volume. The power required for the pump

is approximately 4 per cent of the output of the engine.

Governing. The governing is by a governor which regulates the amount of fuel supplied to the engine. The governor holds the suction valve of the fuel pump open for a portion of the forcing stroke, or regulates the length of the stroke of the pump, or varies the clearance of the pump. Each manufacturer employs a different method for governing, but all methods in use seem to give a close regulation. If the engine has more than one cylinder, each cylinder must have its own pump and all pumps must be under the control of the governor. As far as the author knows, no one has attempted to distribute the oil to the various cylinders after it leaves a common fuel pump.

The regulation is well under 3 per cent in all types, and, if necessary, some manufacturers are willing to guarantee much closer regulation. All engines, except the single cylinder types, will give close enough regulation for operation of all electrical machinery. The overload capacity of the Diesel engine is small when compared to turbines as it is only about 10 to 15 per cent.

Water Cooling. The cylinders and cylinder heads of all Diesel engines must be watercooled, and in the larger sizes the pistons must be cooled also. The amount of water required is about 3 to 9 gal. per b.h.p. per hour, depending upon the temperature rise which is allowed. With a temperature rise of 70 deg. fahr. the amount of water will be about 3 to 4 gallons. The maximum temperature of the cooling water is kept about 130 to 140 deg. fahr., although it may rise to as high as 180 deg. fahr. if the water contains no impurities that will precipitate at this temperature. The heat carried away in the cooling water is about 2500 to 3000 B.t.u. per b.h.p. per hour.

FUELS

Any fuel that will burn without leaving an ash or residue, either due to incomplete combustion or due to unburnable material in the fuel, may be used in a Diesel engine. Attempts have been made to introduce pulverized coal into the cylinder of the engine, but these have not as yet been successful. Gasoline, kerosene and the light distillates need not be considered as fuel for the Diesel engine as they can be used to better advantage elsewhere.

There is left crude oil, low-grade distillates and the coal tar products. The last have not been used to any great extent in this country.

Crude oil which is free from sand and water can be used as fuel, even if it contains as much as 50 per cent asphaltum. Owing to the scarcity of gasoline, today practically all crude oil has the gasoline content removed before it is sold for fuel, so that all fuel oil is "topped" oil.

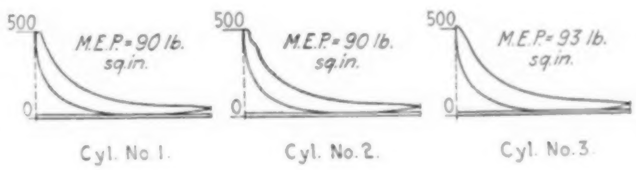
On the Pacific Coast we are not interested in the Eastern oils, but I would like to say that when used in Diesel engines these have given better satisfaction than the Western oils. The California oils have been tried on the manufacturers' testing floors in the Eastern states, and all reports that the author has received indicate that they have been satisfactory. But, at the same time, the statement is made that the tests have not been continued for more than 6 to 7 days as the supply of the special oil becomes exhausted. After such tests the condition of the engine is always reported to be excellent. The objections that the author has heard against the Western crude oils are these: Viscous and sluggish, high sulphur content, high water content, and high in ash.

A viscous and sluggish oil can be heated by the cooling water as it leaves the engine, or by the hot exhaust gases, until it becomes fluid. It can then be pumped as well as any oil. When such an oil is employed kerosene should be used to start up with and for a few minutes before shutting down, so as to clean out all the heavy oil from the piping and pumps.

The high sulphur content oil is more dangerous, as it burns to sulphur dioxide which tends to cause corrosion of the piston and cylinder, the valves and valve seats and the exhaust pipe. The maximum amount of sulphur that can be allowed seems to be about 2 to 4 per cent.

Water in the oil will decrease the heating value and cut down the amount of fuel delivered to the cylinder. If the water comes in "slugs" it will cause the engine to run irregularly. "Topped" oil will not contain much water, as it will be removed during the topping process. Most manufacturers specify an oil containing less than 1 to 2 per cent of water.

The ash is of considerable importance as it tends to remain in the cylinder, causing cutting of the walls, the valves and the valve seats. This makes the maintenance charges high. The Eastern paraffine base oils can be cleaned much easier than the Western asphaltum base oils. In the latter the asphalt collects around the sand particles, and it is impossible to separate them except by heating the oil and straining it while hot.



Scale of spring, 400 lb.
Injection Air Pressure, 1045 lb. per sq. in. abs.

Fig. 6 Indicator Cards from 3-Cyl. Lyons-Atlas Diesel Engine

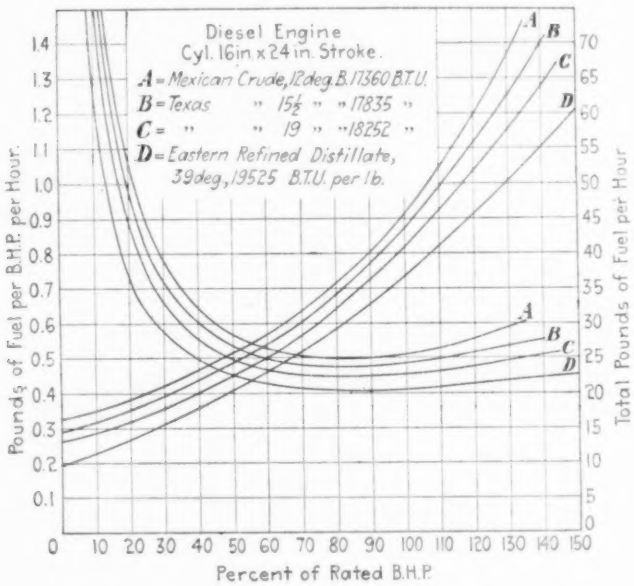
Some engines are working today on Western oils being sold in the market as boiler fuel oil. The Diesel engine located on the Jameson ranch at Corona, Cal., is now running on 24 to 26 deg. Beaumé Santa Fé tops bought for the smudge pots. The oil costs 69 cents per barrel, f. o. b. Los Angeles. This engine has been run for more than 2 months without a shut-down. About a quart of coal oil was supplied twice a day to clean out the pump. The engine was run for 10 days on 18 deg. fuel oil then in use on a steam road roller in Corona, and the run was stopped at the end of that period, as the supply of that particular fuel was exhausted.

The Lyons-Atlas Company sold a 600 b.h.p. engine to the Hawaiian Commercial and Sugar Company on the guarantee of 710 hours operation out of 720 per month on 14 to 18 deg. California oil, then in use under the company's boilers in the Hawaiian Islands. The engine was tested at the factory under the supervision of the company's engineer, was paid for, and then shipped through the Panama Canal to the Islands. The test consisted of a 48-hour preliminary run on Eastern oil and then a 144-hour (6 day) continuous run at

rated load on the California oil. At the end of the run, the valves and the heads were examined and no evidence of any deposit was found. A 120 h.p. 4-cycle engine has been running for 6 months, 24 hours a day, without a stop, in San Antonio, Texas. The fuel was a 20-deg. Texas oil. There are numerous other examples of engines on this coast, but not using California oils. Many engines are in operation in Texas, New Mexico and Arizona using Texas and Mexican oils.

ECONOMY AND EFFICIENCY

The economy of the Diesel engine is the best of all present engines. Fig. 4 shows the heat balance for a 4-cycle Diesel engine, and also for one of the latest large steam turbine plants. In preparing this heat balance for the Diesel engine, a mechanical efficiency of 77 per cent was assumed and the thermal efficiency of an actual engine, as shown by test, was used as a basis for the remainder. The distribution of waste heat between exhaust and cooling water for this engine varies, so that an equal distribution was assumed.



Curves starting lower left hand corner show total fuel

FIG. 7 DIESEL ENGINE, COMPARISON OF FUELS

The heat balance of the turbine plant is a composite heat balance based upon an oil-fired boiler and a turbine generator unit, using the best steam figure that I have record of; 95 per cent is allowed for the efficiency of the generator and 95 per cent for the mechanical efficiency of the turbine.

The author's idea in making this comparison is to show the best thermal efficiency in both types of prime movers, thus indicating the superiority of the Diesel engine as far as thermal efficiency is concerned. So far as is known, however, no steam turbine plant is operating today with an overall thermal efficiency quite as high as the 20 per cent shown.

The efficiency of the Diesel engine may be still further increased by utilizing the heat in the exhaust for making steam to run a steam turbine. Experiments are now being carried out in this direction, but the results are not yet good enough to indicate that this can be done in all cases. Experiments are also being made along the line of increasing the temperature of the jacket water, so that this may be converted into steam which may be used.

Figs. 5 and 6 show respectively efficiency curves and indicator cards for a 3-cylinder Lyons-Atlas Diesel engine, using an Eastern oil. Fig. 5 shows clearly that from about 60 per cent to 120 per cent of the rated load the economy and thermal efficiency remain nearly constant. The mechanical efficiency tends to increase as the load increases. This factor is about 75 per cent at full load for a 4-cycle engine and 70 per cent for a 2-cycle engine. (This is due to the power required for the air compressor for the scavenging air.)

Fig. 7 shows the results of a series of tests on an engine, using various fuels. When the best grade of fuel indicated is used, the amount is about 0.4 lb. per b.h.p-hr., while it does not exceed 0.5 lb. with the poorest grade at rated load.

The Diesel engine will work nearer to test conditions at all times than any other type of prime mover, as it is more independent of the operator and requires a good compression for ignition. The efficiency depends upon the compres ion; if this latter drops due to valve trouble the engine will show it at once, as there will not be heat enough to igr ite the fuel.

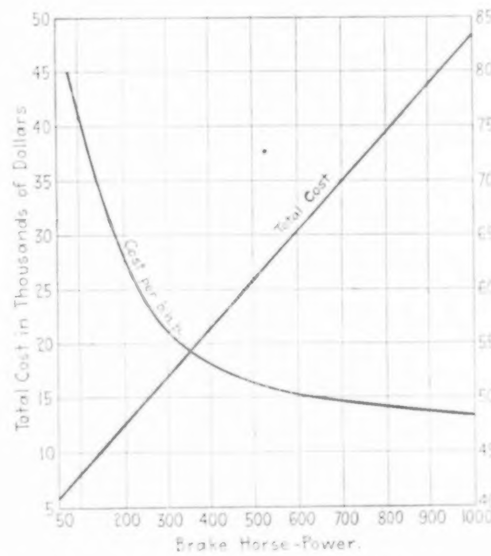


FIG. 8 COST OF DIESEL ENGINES, F.O.B. LOS ANGELES, CAL.

OPERATING AND DEPRECIATION

The amount of lubricating oil is stated to be about 0.01 pint per b.h.p. per hour, based on the rated load. The engine at Corona uses 3 quarts of oil every 24 hours to supply the loss. The load is about 35 h.p. while the rating of the engine is 65 h.p. This is at the rate of 0.008 pint per h.p. per hour.

One engineer can handle 1000 to 1500 horsepower per shift. The attendance consists in keeping the engine supplied with both fuel and lubricating oil and the minor work that there always is around a power plant. Operators and manufacturers say that it is necessary to examine the fuel valve and the exhaust valves periodically and clean them. The time interval for this depends upon the kind of fuel in use—it may be a week or several months.

The question of maintenance and depreciation is still an open one. The maintenance charges per year seem to average

about 1 per cent of the first cost of the engine. Very few manufacturers have yet had engines in service for any length of time, so that the life of the engine is still uncertain, although it is claimed to be longer than that of a steam engine. The Busch-Sulzer Diesel Engine Company have two 225 b.h.p. engines installed in Texas which were put in over nine years ago; these have been operating on an average of 18 hours a day. The cylinders have never been rebored and now show very little wear and are as smooth and bright as glass. The same company also has a 225 b.h.p. engine in Illinois which has been working for 24 hours a day, $6\frac{3}{4}$ days a week, for over $2\frac{1}{2}$ years, with only two minor shut downs.

The following facts seem to be fairly well established:

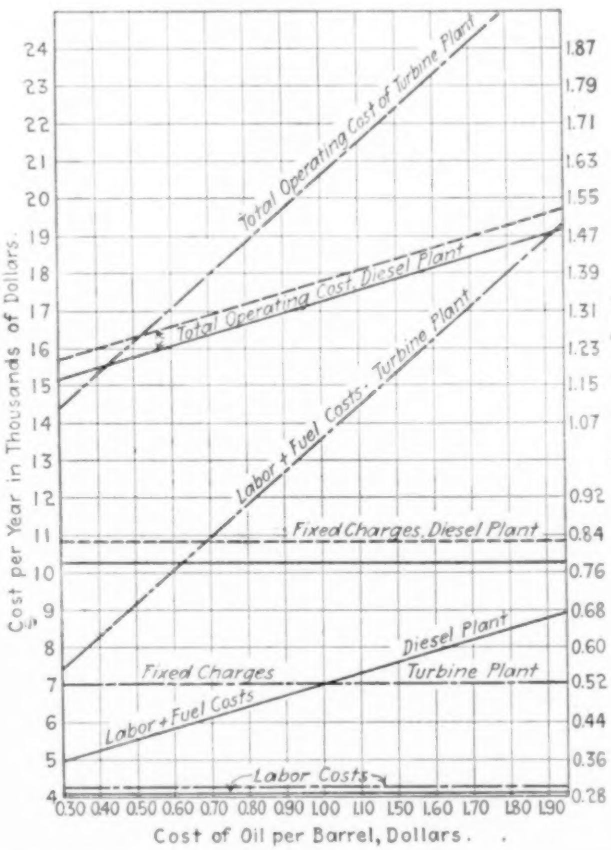


FIG. 9 COMPARISON COST CURVES, STEAM TURBINE AND DIESEL ENGINE, 600 KW. MUNICIPAL LIGHTING PLANT

1 The Diesel engine can operate continuously for $6\frac{1}{2}$ or more days out of seven
2 This can be kept up for long periods if a short interval is allowed for overhauling and minor repairs
3 The exhaust valves may give trouble by burning if the load is too large
4 The air compressor may give more trouble than the engine if it is not watched
5 Dirt in the oil will give trouble
6 Water in the oil will give trouble
7 The engine will not carry much more than its rated load for any length of time.

WEIGHTS AND COSTS

The weight of the Diesel engine per horsepower varies considerably, even for the same size of engine. Data supplied by the manufacturers in this country show that the weight per b.h.p. varies from 250 to 500 lb., with no uniformity, except that the higher-priced engines are the

TABLE 1 COMPARISON COSTS, STEAM TURBINE AND DIESEL ENGINE, 600 KW. MUNICIPAL POWER PLANT

ASSUMPTIONS

Load Factor = 25 per cent Maximum load = rated output
(This gives turbines slight advantage in overload capacity)
Turbines operated condensing, using jet condenser and cooling tower. Oil Fuel.
Crude oil, 95 cents bbl. Distilled oil, $1.50 bbl.
Turbine Plant develops 140 kw-hr. per bbl.
Diesel Plant develops 447 kw-hr. per bbl.

FIRST COST

TURBINE PLANT		DIESEL ENGINE PLANT			
1-200 kw., 1-400 kw. Units		3-200 kw. Units		1-200 kw., 1-400 kw. Units	
Boilers & Settings	$ 6,200	Engines	$51,000	Engines	$47,500
Pumps	250	Erecting	5,000	Erecting	5,000
Piping	500	Piping	1,400	Piping	1,400
Stack and Flues	2,950	Oil tanks	1,000	Oil tanks	1,000
Heaters	500	Water Cooling Apparatus	1,000	Water Cooling Apparatus	1,000
Turbines	12,500	Generators	11,400	Generators	11,400
Generators, etc	11,400	Building	6,000	Building	6,000
Condensers	2,400				
Cooling tower	3,500				
Building	10,000				
Total	$50,200	Total	$76,800	Total	$73,300

OPERATING COSTS, 1,314,000 kw-hr. per Year

TURBINE PLANT		DIESEL ENGINE PLANT			
Wages	$3,000	Wages	$3,000		
Lubrication	500	Lubrication	500		
Miscellaneous	100	Miscellaneous	100		
Maintenance	400	Maintenance	400		
Water	250	Water	50		
	$4,250		$4,050		
		3 Engines		2 Engines	
		Fuel		Fuel	
		95 cents bbl.	$1.50 bbl.	95 cents bbl.	$1.50 bbl.
Fuel at 95 cents per bbl.	$8,910	Fuel $ 2,790	$ 4,410	$ 2,790	$ 4,410
Fixed charges 14 per cent	7,030	Fixed Charges 14 per cent 10,780	10,780	10,280	10,280
Total	$20,190	Total $17,620	$19,240	$17,120	$18,740

DISCUSSION OF THESE VALUES

Difference in first costs = $73,300 − $50,200 = $23,100.
Diesel Engine Plant costs 46 per cent more.
Difference in operating costs.
(a) $20,190 − $17,120 = $3,070. Net saving per year = $3,070.
(b) $20,190 − $18,740 = $1,450. Net saving per year = $1,450

Conclusion: Difference in yearly cost is so small that no definite conclusion can be drawn.

Each plant should be investigated carefully before the type of equipment is decided upon.

heavier. In an issue of London ENGINEERING during 1914, the statement was made that in European practice the weight had been reduced to 62 lb., but this was an exception.

The cost of the engine is hard to determine, as it varies so much and manufacturers do not like to supply cost data. The

price increases directly with size of engine from $6000 for a 75 h.p. engine to about $48,000 for a 1000 h.p. engine. The price of a small Diesel engine is prohibitive and that for large engines of several thousand horsepower does not go much below $45 per horsepower. Curves of costs plotted from data supplied by several manufacturers are given in Fig. 8.

COST OF A SMALL PLANT

Table 1 shows a comparison of the cost of steam turbine and Diesel engine plants, 600 kw. The plants are suppositious, but the cost figures given can be considered as approximately correct. They show that the Diesel may enter into serious competition with the steam plant when the load factor is better than 25 per cent. The Diesel engine will not replace the steam plant until much more definite figures are secured regarding the life of the former.

As the yearly load factor is increased the Diesel engine will show a saving in total operating cost due to the saving in fuel. In the steam plant the fuel item is the largest single item of expense, with the fixed charges next. In the Diesel plant the fixed charges are the largest single item, with the remainder of the operating cost about equally divided between fuel and labor, water, etc.

The items under first cost of the two plants are only approximately correct, as the author had no personal data available and had to depend upon published results which did not check with one another. The output per barrel of oil is based upon published yearly reports of both Diesel and steam plants. The steam plant is located in California while the Diesel plant is in Texas. The distilled oil cost was purposely placed high, so as to indicate the showing that a Diesel engine could make in competition with a steam plant, even if it was handicapped with a high price of suitable oil. As we are not interested in comparison of coal and oil as fuels, no attempt has been made to show such. The items under operating cost were taken from a published report of a Diesel plant in Texas, where wages are low in comparison to those in California. In the turbine plant about the same conditions of operating have been assumed, as the total of the items listed under lubrication and miscellaneous are small.

In Fig. 9 showing cost curves are plotted the yearly costs for the plants against price of oil per barrel. This shows graphically the effect of the price of oil on the total operating cost. By projecting from the total operating cost curve of the steam turbine plant to the corresponding curve for the Diesel plant, a comparison may be secured for any price of oil. For example, assume the price of boiler fuel oil to be 75 cents and engine oil to be 90 cents per barrel. Then the turbine plant will cost $18,400 per year, and the Diesel plant $17,500 per year. When the price of oil is 53 cents per barrel, the yearly cost will be about the same for both plants.

On account of the lack of data relative to the life of the Diesel engine, the same fixed charges, namely, 6 per cent depreciation, 6 per cent interest and 2 per cent insurance and taxes, have been assumed alike for both plants for comparison.

The item of life of the Diesel engine is open for discussion, but no one can yet say definitely what the life of the Diesel engine, properly taken care of, is going to be, as none of our successful plants have been in operation long enough to give the answer.

THE HEAVY OIL ENGINE, ITS PRESENT STATUS AND FUTURE DEVELOPMENT

BY A. H. GOLDINGHAM, NEW YORK

Member of the Society

SINCE the oil engine was invented, about 1870, rapid progress has been made with it. This is best demonstrated by reference to the indicator diagrams, Figs. 1 to 8, taken from engines built during the past twenty-seven years.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

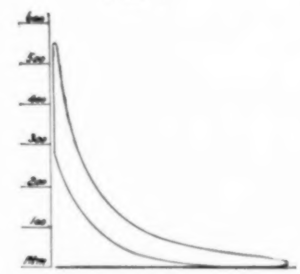


Fig. 6

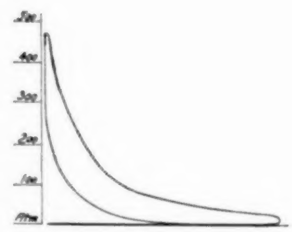


Fig. 7

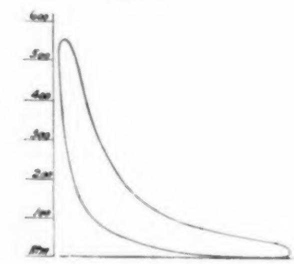


Fig. 8

Indicator Diagrams showing Progress in Oil Engines since 1888

The first diagram was taken from a Priestman oil engine, 1888 type, cylinder $10\frac{3}{4}$ in. diameter, stroke 14 in., 160 r.p.m. The initial pressure was 125 lb. per sq. in., exhaust pressure 24 lb., compression pressure 20 lb. and m.e.p. 44 lb. The b.h.p. developed was 8.4, using fuel with a heating value of 19,000 B.t.u. and specific gravity 0.853. The fuel consumption was 1.05 lb. per b.h.p-hr. and the thermal efficiency 12.8 per cent. All these figures represent average conditions.

Author's Note: The distillate engine largely in operation in the Pacific Coast States is not discussed in this paper. Only engines using heavy fuels are referred to.

Presented at the Panama-Pacific International Exposition meeting, San Francisco, September 1915, of The American Society of Mechanical Engineers. The paper may be obtained in pamphlet form; price, 10 cents to members, 20 cents to non-members.

The fuel was sprayed into an external vaporizer (separate from the cylinder), heated by the exhaust gases, the ignition being effected by an electric ignitor.

Fig. 2 is a card from a Hornsby-Akroyd engine, 1890 type, with hot-surface vaporizer constructed without the partial water jacket of later engines, and with very low compression pressure. The engine represented developed 6 b.h.p. at 216 r.p.m., with fuel having a heating value of 19,000 B.t.u. and specific gravity 0.8410. Fuel consumption 1.0 lb. per b.h.p-hr. and thermal efficiency 13.5 per cent. The initial pressure was 120 lb. per sq. in., exhaust pressure 20 lb., compression pressure 40 lb. and m.e.p. 35 lb.

In subsequent types of the same engine, the compression pressure was increased with consequent increase in thermal efficiency.

This is shown in Figs. 3 and 4, which are diagrams from 1893 and 1905 types Hornsby-Akroyd engines respectively. Fig. 3 represents an 8.02-in. by 14-in. engine developing 5 b.h.p. at 214 r.p.m.; initial pressure 120 lb. per sq. in., exhaust pressure 22 lb., compression pressure 46 lb., m.e.p. 37.5 lb.; heating value of fuel 18,600 B.t.u., specific gravity 0.824, fuel consumption 0.99 lb. per b.h.p-hr. Thermal efficiency 13.8 per cent.

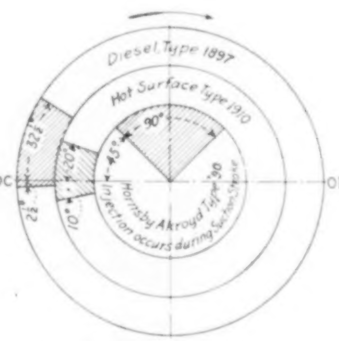


Fig. 9 Periods of Injection of Fuel

Fig. 4 is taken from an engine with cylinder diameter 14.5 in. and stroke 17 in.; r.p.m. 202; initial pressure 168 lb. per sq. in., exhaust pressure 30 lb., compression pressure 60 lb., and m.e.p. 48 lb. B.h.p. 27. Heating value of fuel 19,000 B.t.u., specific gravity 0.825. Fuel consumption 0.74 lb. per b.h.p-hr. Thermal efficiency 18 per cent.

Fig. 5 is taken from a De La Vergne oil engine, type DH, built in 1913. Cylinder diameter 14 in., stroke 24 in. Initial pressure 325 lb. per sq. in., exhaust pressure 25 lb., compression pressure 169 lb. and m.e.p. 75 lb. Heating value of fuel 18,500 B.t.u., and fuel consumption 0.543 lb. per b.h.p-hr. Brake horsepower 60 at 210 r.p.m. Thermal efficiency 25 per cent.

Fig. 6 is a diagram from a Ruston Proctor engine, type 1913. Initial pressure 550 lb. per sq. in. approximately, exhaust pressure 25 lb., compression pressure 280 lb. and m.e.p. 70 lb. Heating value of fuel 19,000 B.t.u. Fuel consumption 0.46 lb. per b.h.p-hr. Thermal efficiency 29 per cent.

A diagram from a De La Vergne engine, type FH, 1915, is shown in Fig. 7. Cylinder diameter of this engine 17 in. and stroke 27½ in. Initial pressure 475 lb. per sq. in., exhaust pressure 30 lb., compression pressure 260 lb. and m.e.p. 82 lb. Engine develops 100 b.h.p. at 200 r.p.m. Fuel consumption 0.450 lb. per b.h.p-hr. of California crude oil, having a heating value of 18,500 B.t.u. Thermal efficiency 30.5 per cent.

Fig. 8 is taken from a Diesel engine, type 1915, cylinder diameter 18.875 in. and stroke 28.375 in. Initial pressure 550 lb. sq. in., exhaust pressure 40 lb., compression pressure 550 lb. and m.e.p. 95 lb. Heating value of fuel 19,266 B.t.u., and fuel consumption 0.407 lb. per b.h.p-hr. Thermal efficiency 32.5 per cent.

It will be noted from these diagrams that the thermal efficiency, 12.8 per cent in 1888, has through improvement

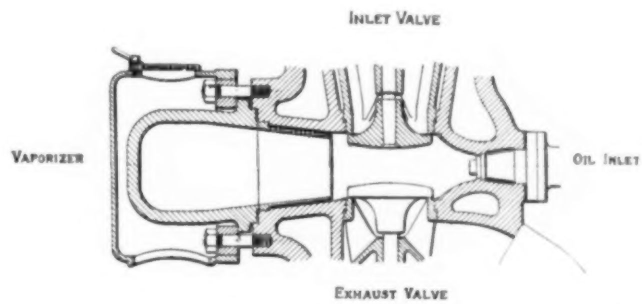


Fig. 10 Cross-Section of Combustion Space of De La Vergne Oil Engine

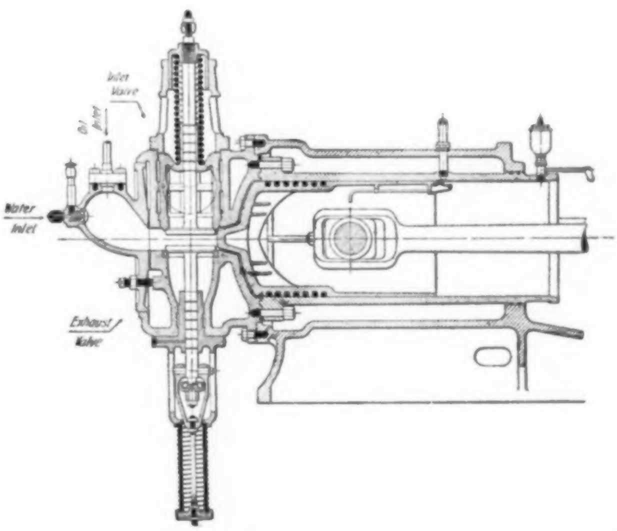


Fig. 11 Section of Ruston Proctor Oil Engine Cylinder

in design and by increased compression pressures in the later engines been increased to 30.5 per cent in the hot-surface type of oil engine. In the Diesel type it is now 32.5 per cent. All calculations are on the basis of brake or actual horsepower and not indicated horsepower.

TYPES OF ENGINES

Previous to about 1892 all oil engines were of either the hot surface or electric ignition type, with the fuel injected during either the first outward stroke of the piston or air inlet period of the cycle. In Fig. 9 are shown the periods of injection in the different types referred to.

A description of the Diesel system was first published about 1892. In the Diesel cycle the fuel injection period did not take place until compression was completed, or nearly so, and the compression pressure was carried to a point where a temperature sufficient to cause ignition was obtained. High

pressure (about 1000 lb.) air was injected with the fuel, thoroughly atomizing or pulverizing it, and thus sufficient pressure to overcome that existing in the combustion space at the time of injection was obtained. This system gave in 1892 the highest thermal efficiency, as it does today.

Realizing that moderate sized oil engines of from about 75 h.p. to about 400 h.p. and a thermal efficiency somewhat less than that attained in the Diesel type and with lower range of pressures could be produced with some advantages and at less expense, various manufacturers in Europe and in this country have built so-called semi-Diesel or hot-surface type engines, embodying the Diesel method of fuel injection, but in some cases without the air blast.

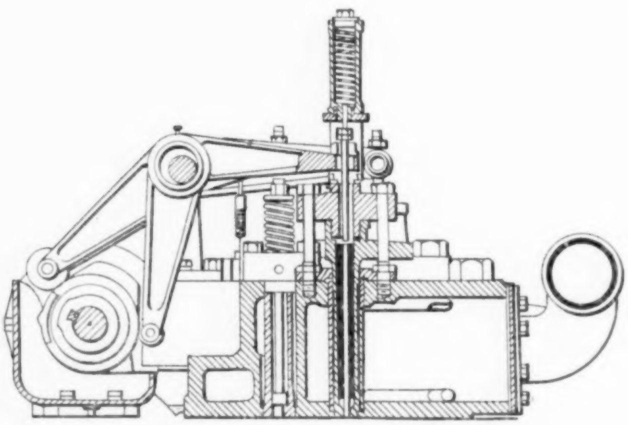


Fig. 12 Section of Willans-Robinson Cylinder Head

Regardless of their cycles of operations, at the present time oil engines may be divided into two classes: *Diesel* and ***hot-surface type*** or ***semi-Diesel***. With the exception of the engine shown in Fig. 16, all engines here illustrated are of the 4-cycle type. The majority of manufacturers in Europe and in this country are building 4-cycle types for stationary and marine purposes. With its comparative simplicity, the 2-cycle engine may have decided advantages in the smaller sizes. In the larger sizes the advantage for stationary service is reduced cost of manufacture, while for marine service, reduced weight and space occupied is also claimed by the advocates of the 2-cycle type. From cylinders of the same dimensions the power is about 70 per cent greater and the fuel consumption is regarded as approximately 10 per cent greater. Accumulated heat in cylinder head and other parts surrounding the combustion space and main crank-shaft bearing troubles have, however, given some European builders considerable difficulty with the 2-cycle type in the larger sizes.

TABLE 1 OPERATION OF FOUR OIL ENGINES DURING 1914

Engine No.	Desired period of operation, hr.	Actual period of operation, hr.	Per cent of desired period
1	6803.80	6684.54	98.25
2 (spare unit)	....	700.47	.....
3	8556.75	8411.55	98.30
4	8626	8457.47	98.05

Figs. 19 and 20 show the combustion space, the fuel inlet and the arrangement of air inlet and exhaust valves of representative Diesel engines.

Fig. 10 is a section of the combustion space of the hot-surface type engine where the fuel and high-pressure air are not injected into the combustion space, as in Figs. 19 and 20, but are first forced into a vaporizing chamber which is heated before starting and in which the temperature is maintained by the combustion of the fuel in it.

The combustion space of another hot-surface type engine in which somewhat of the same system of operation as in the previous engine obtains is illustrated in Fig. 11,[1] but here the air is not injected with the fuel as in the engine in Fig. 10, but a mechanical sprayer or pulverizer is used and a slight amount of water is also allowed to enter the chamber in addition to the fuel.

DESIGN

The general construction of both Diesel and hot-surface types of engines is shown in the different illustrations. Examination of the different details of construction of the very large number of Diesel and other oil engines built in different countries of the world shows many interesting designs.

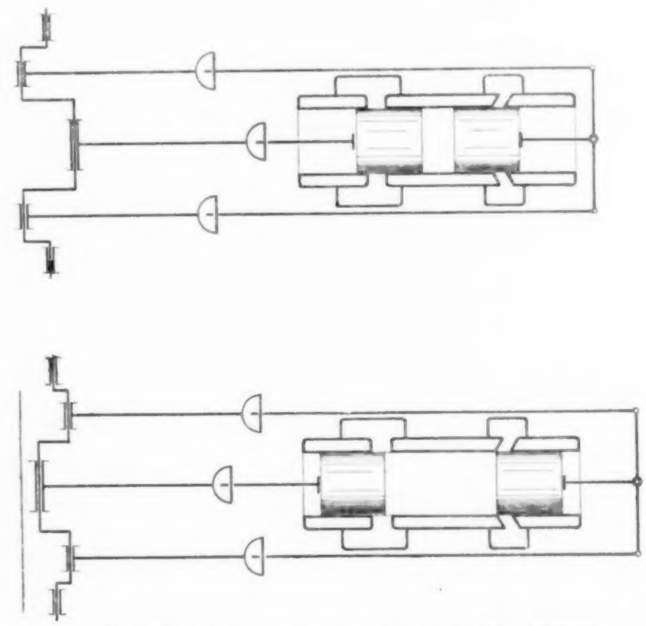


Fig. 13 Arrangement of Junkers Oil Engine

It would not be feasible here to refer to all the different details of construction. Important elements of large modern oil engines are:

a Cylinder heads,
b Trunk piston *or* crosshead and shorter piston,
c Sprayer or pulverizer.

Cylinder Head. Considerable difficulty was in the past experienced with the cylinder heads of Diesel as well as of hot-surface type engines due to fracture largely attributable to high temperatures and pressures obtaining in the combustion space. In recent years this difficulty has been largely or entirely overcome. In some cases the reason for this trouble was improper casting, the cores shifting and causing unequal thicknesses of the walls of the cylinder head. Amended and improved design in modern engines has, in most types, eliminated this trouble. The heads are now made of such

[1] Shown by permission of Messrs. Iliffe & Co., London, Eng.

design and material that uniform thickness of the walls is obtained, and the material (soft charcoal iron or its equivalent) is such as to allow easy and uniform expansion and contraction.

Various designs of cylinder heads, among which the following are of interest, have been made to simplify the castings: Fig. 12[1] shows the cylinder head of the engine made by Willans-Robinson, Rugby, England, and by the Dow Steam Pump Co. in California. This is a notable design and with it the strains due to contraction in the foundry are reduced. In this cylinder head recesses are only made for the insertion of the air inlet and exhaust valves. The fuel inlet valve is inserted in a tube which has different diameters at its ends and which is pressed into place between the lower and upper facings of the walls of the cylinder head. The starting

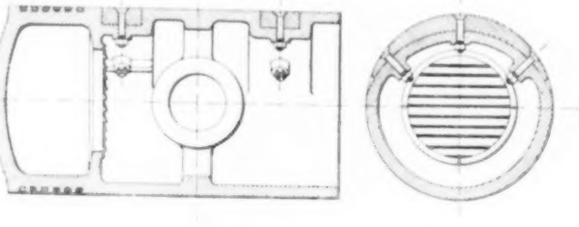


FIG. 14 SECTION OF M. A. N. PISTON

air valve is similarly inserted in a separate tube. No recess is cored in the cylinder head for these valves and in this way the shape of the castings is simplified and unequal masses of metal are eliminated.

A part section of the Junkers type of Diesel engine in which the cylinder head is eliminated entirely is shown in Fig. 13. This engine is equipped with two pistons in each cylinder, that farther from the crankshaft moving in the opposite direction to that nearer the crankshaft and both being connected by suitable crosshead and connecting rods to the outside cranks at 180 deg. from the main crank. In this type, the fuel is injected into the combustion space formed between the two pistons.

Piston and Crosshead. The trunk piston without crosshead is shown in Figs. 19 and 20. In 4-cycle, single-acting engines developing over 150 h.p. in one cylinder a cross-

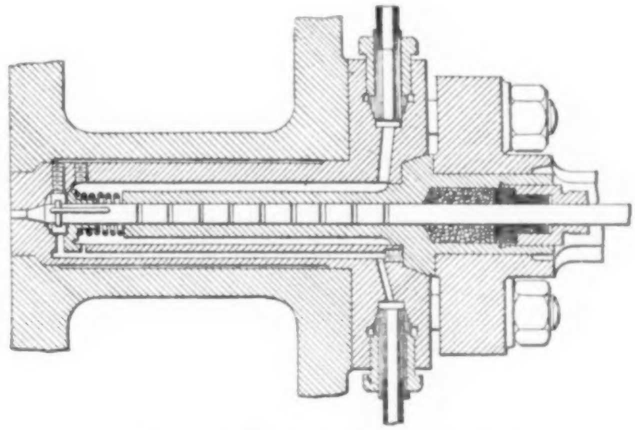


FIG. 15 SECTION OF SABATHE SPRAYER

head is recommended. The advantages of the crosshead type may thus be stated:

(1) The guides in which the crosshead moves are maintained at an even temperature and are not subject to the expansion and contraction of the cylinder that they are with the trunk piston.

(2) It is simpler to lubricate the crosshead pin than the trunk piston pin, as the former does not come in contact with the heated parts of the engine.

[1] Figs. 12, 15, 19 and 20 are reproduced by special permission of Messrs. Spon and Chamberlain, publishers of "Marine and Stationary Diesel Engines," by the author (in press).

TABLE 2 POWER GENERATION COSTS FOR 1914

Estimated output		Oil consumed				Cost of operation, dollars								
				Lb. per		Labor		Materials and supplies						Total cost dollars
At switchboard kw-hr.	At engines h.p-hr.	Gal.	Lb.	Kw-hr. switchboard	H.p-hr. engines	Operating	Maintenance	Fuel oil 16½c. gal.	Lubricating oil 71c. per 1000 h.p-hr.	Repair parts	Belts	Misc. supplies	
2,469,293	3,996,196	278,595	2,061,602	0.84	0.52	7907.31	2211.76	46603.62	2838.82	1659.50	792.92	1044.64	63058.57
Per kw-hr......	....	0.113	0.835	....	....	0.0032	0.0009	0.0188	0.0011	0.0007	0.0008	....	0.0255
Per h.p-hr....	....	0.083	0.516	....	....	0.0020	0.0006	0.0116	0.0007	0.0004	0.0005	....	0.0158
								Fuel oil 2 1/7c. gal.	Lubricating oil 35c. per 1000 h.p-hr.				
	....	....	....	....	....	....	....	5969.29	1400.00	....	....	....	20985.42
Per kw-hr......	....	....	....	....	....	....	....	0.0024	0.00057	....	....	....	0.0086
Per h.p-hr.....	....	....	....	....	....	....	....	0.0015	0.00035	....	....	....	0.0053

Based on 8640 hr. per year, that is with fuel at 16.5c. per gallon and lubricating oil 71c. per 1000 h.p-hr. equivalent to: $136.51 per h.p. year at the engines; 164.41 per kw. year at the switchboard

Or with fuel oil at 2 1/7c. per gallon and lubricant at 35c. per 1000 h.p. hours equivalent to: $45.70 per h.p. year at the engines; 74.50 per kw. year at the switchboard

The last named figures are given showing costs under ordinary conditions. Allowance must be made for increased cost of materials and supplies due to excessive charge for transportation.

(3) The guides of the crosshead type can be more easily adjusted, whereas the ordinary trunk piston does not allow of adjustment.

Advocates of the trunk piston in preference to the crosshead type point out that the wear in the cylinder is due to the piston rings and not to the friction of the trunk piston, that in a well designed engine the pressure of the piston on the cylinder walls is so slight, its proper lubrication can easily be maintained and that the crosshead type requires more space and is more expensive to manufacture.

Fig. 14 shows the type of piston made by the M. A. N. in Germany. This is equipped with loose strips on its upper surface which permit adjustment to take up the wear on the piston. The makers of this type claim for it the advantages of a crosshead without the disadvantages of greater cost of manufacture and the occupation of more space.

Sprayer or Pulverizer. A most important feature of all oil engines is the sprayer or pulverizer through which the fuel and high-pressure air are injected into the combustion space. Its function is to thoroughly atomize the fuel and mix the particles with the air before the latter enters or as it enters the combustion space.

Where a heavy crude oil or tar is the fuel, a slight amount of lighter fuel is used in addition. The sprayer is then equipped with two openings and passages properly arranged so that the lighter fuel enters the combustion space and ignites before the heavier fuel enters. The temperature is raised and the ignition of the heavier fuel is facilitated. Separate fuel pumps are used for each fuel.

An interesting fuel inlet valve is that used by the Société des Moteurs Sabathé with their engine for submarine use; this valve is shown in section in Fig. 15. It is equipped with

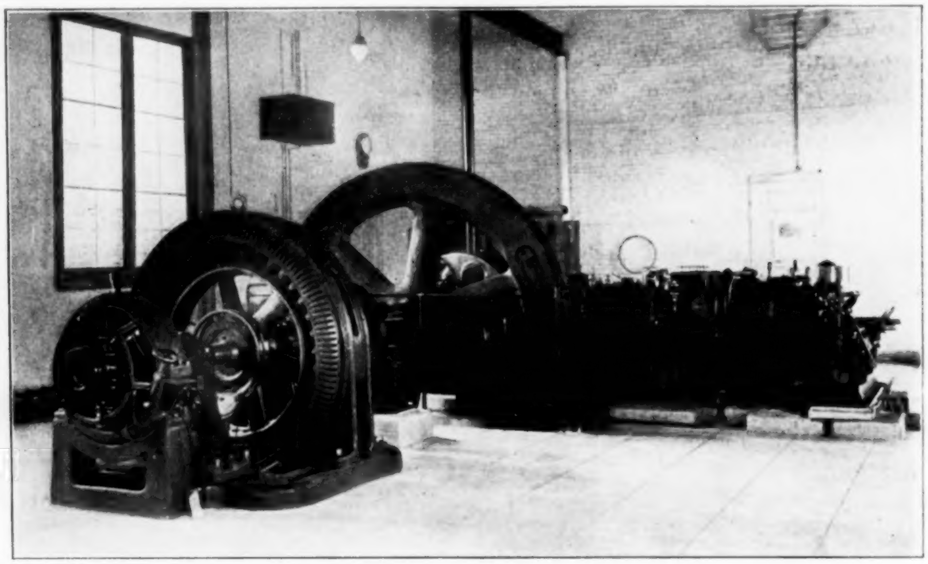


Fig. 16 250-h.p. 2-Cycle Snow Oil Engine

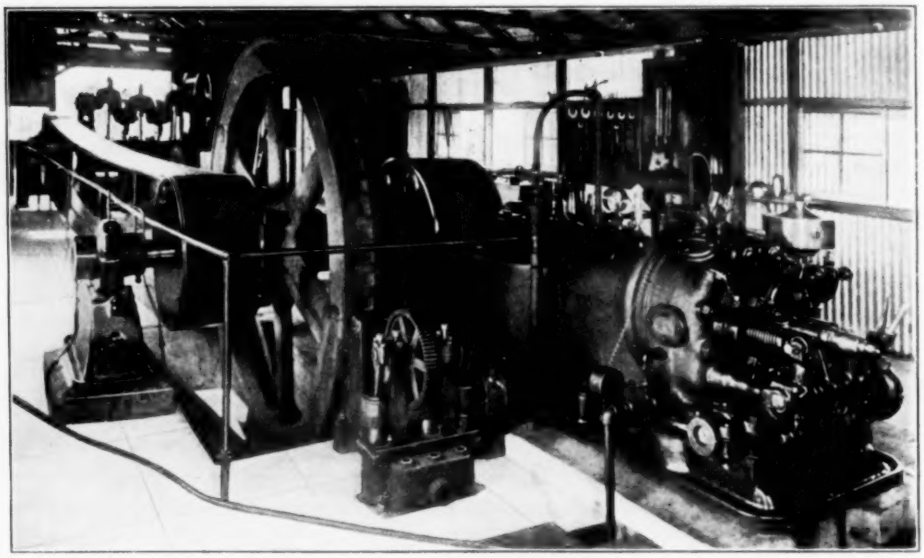


Fig. 17 60-h.p. 4-Cycle Snow Oil Engine

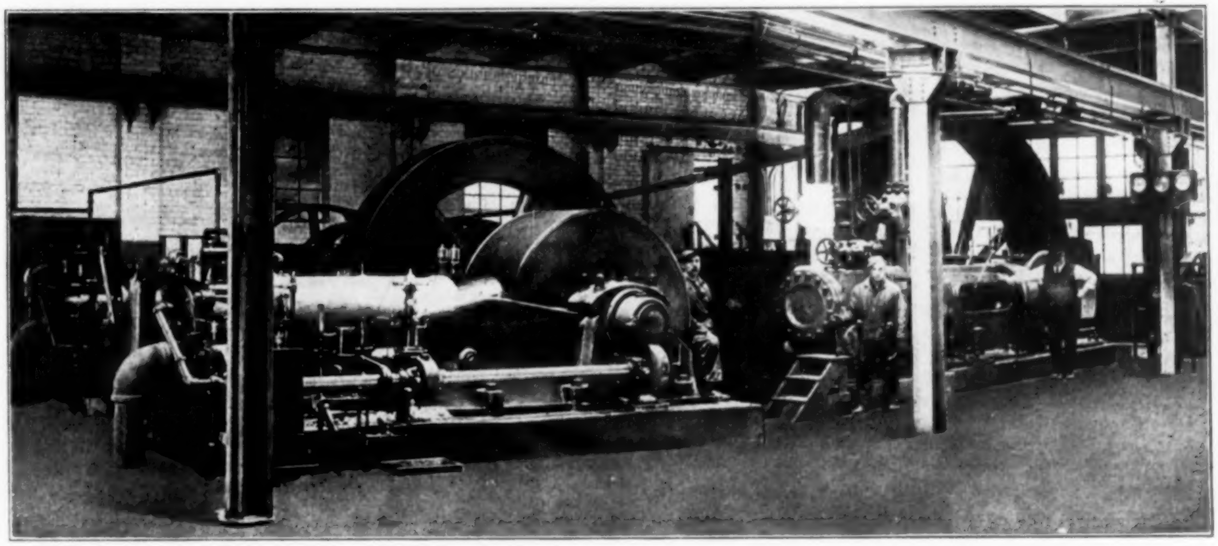


Fig. 18 De La Vergne Oil Engine at Oakland, Cal.

two valves, one of which is the ordinary type of fuel inlet valve and the second is larger in diameter and loose on the former, being held in place by the spring as shown. This fuel inlet arrangement is designed to effect "mixed combustion" by allowing two periods of fuel injection. Its principle is as follows: The fuel injection from the first valve is arranged to enter the combustion space when the compression is about 450 lb. and the volume is constant, with the result that the pressure instantly rises. Immediately afterwards the injection of fuel from the upper passage hitherto held in check by the larger valve is allowed to slowly enter the combustion space while the volume is increasing. The movement of the valves is, of course, mechanically controlled and the timing of injection can be altered to suit the requirements of varying speeds. Economy of injection air as well as greater efficiency is claimed for this type.

TABLE 3 COMPARISON OF DIESEL MOTOR SHIP AND STEAMSHIP

	Steamship "Kina" (Single screw)	Motor ship "Siam" (Twin screw)
Length between perpendiculars, ft.	385	410
Breadth, ft	53	55
Depth moulded	26 ft. 10¾ in.	30 ft, 6 in.
Cargo, tons	7673	8670
Distance covered, miles	27808	27818
Fuel, tons	4858.6, coal	1120.2, oil
Cost of fuel, dollars	5.25 (22 sh)	7.25 (35 sh) oil
Fuel cost, dollars, 1000 tons cargo 1 mile at 11 knots	13.6 (6.08 d)	4.0 (2 d)
Fuel cost, dollars, 8500 tons 27.818 miles at 11 knots	28.702	9.400
Saving in favor of motor ship, dollars	19.302	

Circuit of Europe, East Asia and return.
Extract from paper read by Mr. I. Knudsen, Malmo, Sweden, July, 1914.

RELIABILITY AND ECONOMY

One of the most important questions of the operation of oil engines and one frequently discussed and referred to by those who are not fully informed on the subject, or who are seeking information, is in regard to reliability of operation. The most forcible reply is that many oil engines have operated in different installations, some for three months, some for six and others for eight months continuously, day and night without stoppage, and with different crude oils.

Table 1 is taken from the records of a mining plant in

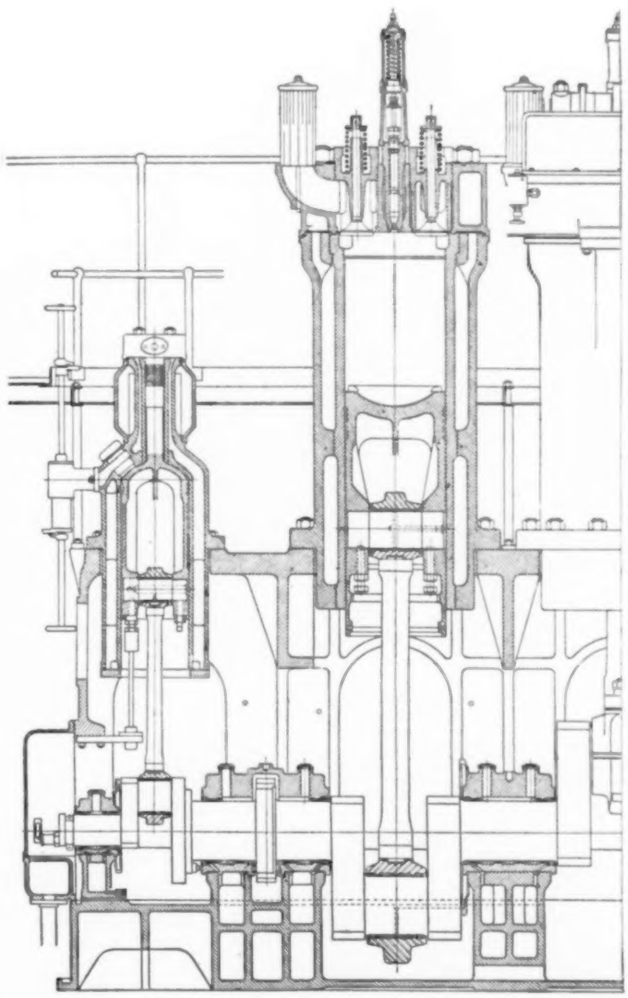


Fig. 19 Section of McIntosh and Seymour Oil Engine

TABLE 4 COMPARISON OF ENGINE FUELS

Maker	Union Oil Co.	Union Oil Co.	Std. Oil Co.	Std. Oil Co.	Union Oil Co.	General Petroleum Co. National Petroleum Co.		
Trade name	California crude	Diesel oil	Calol fuel oil	Star fuel oil	Stove oil	Kellogs stove dist. hvy. slush tops	Kellogs No. 2 tops dist.	No. 1 water white dist.
Gravity at 60 deg. in deg. Beaumé	14– 18	23.5–24	24	27.2	28	36–40	43–45	48–51
Flashpoint (Abel-Pentsky) burning pt. closed cup deg. fahr.	150–175	175–185	150	190	175	100	50	25–30
	175–225	......	......	225	210	125	65–75	40–50
Flashpoint open cup burning pt., deg. fahr.	......	195–205	......	210	200	120	63	30–35
	......	235–245	......	243	225	140	72	50–60
B.t.u. per lb.	18,500	18,950–19,250	19,000	19,200	19,300	18,000–19,000	18,000–19,000	18,000–19,000
Sulphur, per cent	usually under 1	0.75	0.75	0.02	0.02	0.02	0.02	0.02
Asphalt, per cent	50	20	25	20	10–20	0.10	0.05	0.001
Water, per cent	usually under 2	0.5	......	0.08	Trace	Trace	None	None
Residue	......	......	......	at 300 deg. fahr. 3 per cent	......	......	at 500 deg. fahr. less than 1 per cent	......

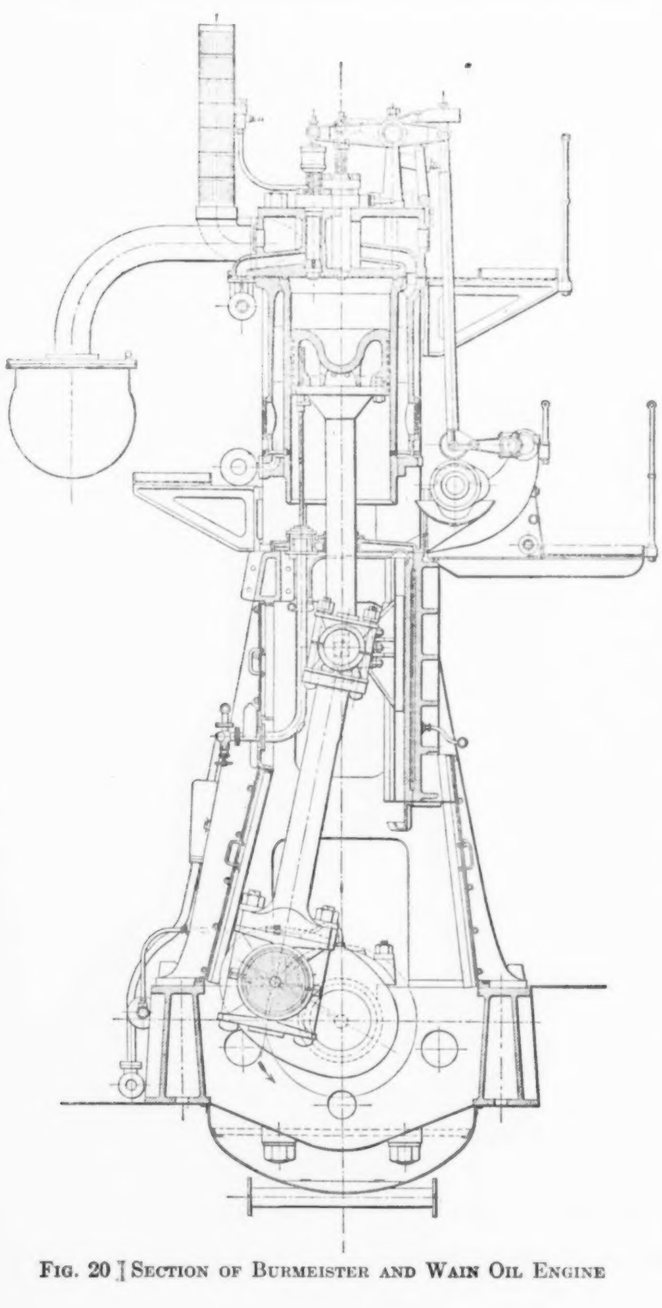


FIG. 20 SECTION OF BURMEISTER AND WAIN OIL ENGINE

Arizona which is operating continuously 24 hr. per day. This plant is equipped with four hot-surface type engines, two of 180 b.h.p., one 250 b.h.p. and one 280 b.h.p., belted to shafting or direct connected to electric generators. The engines are installed at an altitude of about 7000 ft.; they are 90 miles from a railroad station and oil fuel and supplies have to be hauled this distance over mountain roads. The cost of hauling is approximately one cent a pound, which accounts for the high cost of fuel, viz: 16.5 cents per gallon. The engines operate on fuel oil of 22-deg. Beaumé. Table 2 shows power generation costs of the same installation for the year 1914.

The advantage of the oil engine for operating almost any class of machinery in comparison with other prime movers is conceded, but for its economy to be fully realized the load factor should be as high as possible.

EXAMPLES OF ENGINES

Fig. 16 shows a 250-h.p. twin-cylinder 2-cycle Snow Diesel horizontal oil engine, direct connected by flexible coupling to a 60-cycle alternator and operating with California and Mexican crude oils; this engine has been in operation about six months. Fig. 17 shows a 60-h.p. single cylinder 4-cycle horizontal Diesel engine by the same maker, operating with 18-deg. Beaumé California crude oil and driving by belt a deep well pump. This plant has been running about four months.

In Fig. 18 is shown a 280-h.p. type FH De La Vergne oil engine operating an ice machine and electric generator by belt and using California crude oil, 14-deg. Beaumé. This installation is at Oakland, Cal., and has been in operation for about one year. The manufacturers of this engine guarantee it to operate on any fuel or crude oil produced in the United States and Mexico having 18,000 B.t.u. and not more than 1 per cent water. This engine has operated for 800 hr. continuously without stopping. Between Nov. 23, 1914, and July 23, 1915, the plant was in operation 5400 hr. during which period 12,330 tons of ice were manufactured.

Fig. 19 shows a partial sectional view of the McIntosh-Seymour enclosed type vertical 4-cycle 4-cylinder single acting stationary Diesel engine of 500 h.p., with 2-stage air compressor for furnishing high pressure injection air placed in line with the motor cylinders and operated, as is now standard practice, from an overhung crank on the main crankshaft.

This drawing shows one of the most recently developed Diesel vertical engines in this country. The details of design, such as cooling, pulverizing of the fuel, valve motion, etc., have had careful attention. While the illustration shows the enclosed crank case type of engine, the latter is also made with "A" frame construction.

The Burmeister and Wain Diesel marine 4-cycle single acting type engine built by this firm in Copenhagen, Denmark, and installed in the latest motor ships made by them is shown in Fig. 20. Each engine has six cylinders, 29 9/64-in. diameter and 43 5/16-in. stroke, and develops 2000 i.h.p. at 100 r.p.m. The engines are reversible by longitudinal movement of the camshaft in the regular way.

There are many interesting features in this engine, notably the spray valve which has two coned surfaces, one forming the valve seat and the other spreading the spray. It opens outward towards the piston, instead of inwards as in most types; in this way the spray of fuel is very evenly distributed throughout the whole of the combustion space and the heat evolved during combustion is distributed over the whole area of the piston. The process of starting and maneuvering is simplified by the starting valve which is automatically operated by the pressure of the air and only requires the opening of one valve. In this type of engine the camshaft is operated from the crankshaft by a chain of spur gears, which system has replaced the vertical intermediate shaft and gearing previously used.

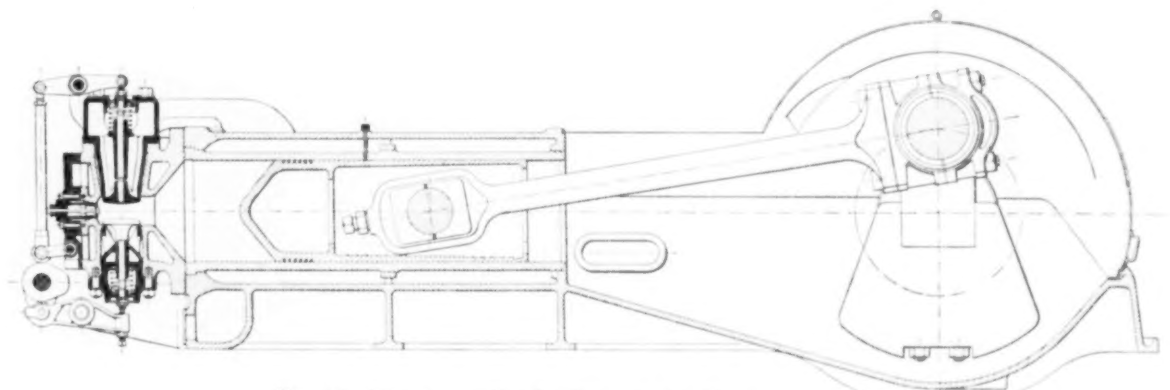


FIG. 21 SECTION OF DE LA VERGNE OIL ENGINE

This design is considered one of the most successful marine engines in large sizes and several motor ships equipped with it have made long voyages. In a paper by I. Knudsen, read in July, 1914, at Malmo, Sweden, the figures in Table 3 showing particulars of a long voyage of one of these motor ships in comparison with a steamship of the same dimensions were given.

TABLE 5 COST OF ENGINE OPERATION

Size of unit	Type of engine	b.h.p. per gal. fuel	Fuel cost per gal. Cents	First cost per b.h.p. Dollars	Total first cost Dollars	Yearly fixed 20 per cent charge, Dollars	Fuel cost 24 hr. per day for 100 150 200 250 days Dollars				Total yearly charge, fuel plus fixed charges 100 150 200 250 days Dollars			
							100	150	200	250	100	150	200	250
50 h.p.	Distillates	10	5	25	1250	250	600	900	1200	1500	850	1150	1450	1750
	Tops distillates	10	2 3/4	25	1250	250	330	495	660	825	580	745	910	1075
	Semi-Diesel	10	2 1/7	60	3000	600	257	385	514	624	857	985	1114	1242
	Diesel	16	2 1/7	75	3750	750	160	241	321	401	910	991	1071	1151
100 h.p.	Distillate	10	5	30	3000	600	1200	1800	2400	3000	1800	2400	3000	3600
	Tops	10	2 3/4	30	3000	600	660	990	1320	1650	1260	1590	1920	2250
	Semi-Diesel	10	2 1/7	55	5500	1100	514	770	1028	1284	1614	1870	2128	2384
	Hot surface-high economy	16	2 1/7	65	6500	1300	320	482	642	802	1620	1782	1942	2142
	Diesel	16	2 1/7	75	7500	1500	320	482	642	802	1820	1982	2142	2302
150 h.p.	Distillate	10	5	30	4500	900	1800	2700	3600	4500	2700	3600	4500	5400
	Tops	10	2 3/4	30	4500	900	990	1485	1980	2475	1890	2385	2880	3375
	Semi-Diesel	10	2 1/7	50	7500	1500	771	1155	1542	1926	2271	2655	3042	3426
	Hot surface-high economy	16	2 1/7	65	9750	1950	480	723	962	1203	2430	2673	2912	3153
	Diesel	16	2 1/7	70	10500	2100	480	723	962	1203	2580	2823	3062	3303
250 h.p.	Distillate	10	5	30	7500	1500	3000	4500	6000	7500	4500	6000	7500	9000
	Tops	10	2 3/4	30	7500	1500	1650	2475	3300	4125	3150	3975	4800	5625
	Semi-Diesel	10	2 1/7	50	12500	2500	1285	1925	2570	3210	3785	4425	5070	5710
	Hot surface-high economy	16	2 1/7	60	15000	3000	800	1202	1605	2005	3800	4202	4605	5005
	Diesel	16	2 1/7	65	16250	3250	800	1202	1605	2005	4050	4452	4854	5255

Yearly fixed charge is arrived at as follows: interest, 6 per cent; taxes and insurance, 1 per cent; repairs, 3 per cent; depreciation, 10 per cent.

Engine using distillate 48–51 deg. B. oil has a thermal efficiency of 20 per cent under full load.
Engine using tops distillate 38–42 deg. B. oil has a thermal efficiency of 20 per cent under full load.
Semi-Diesel engine using 24–28 deg. B. oil has a thermal efficiency of 18 per cent under full load.
Hot surface high economy engine using 16 deg. B. oil has a thermal efficiency of 27 per cent under full load.
Diesel engine using 18 deg. B. oil has a thermal efficiency of 28.4 per cent under full load.

OIL ENGINES IN PIPE LINE SERVICE

Fig. 21 shows a sectional view of the latest design of De La Vergne 150-h.p. single and 300-h.p. twin-cylinder oil engine. In this construction the valve motion consists of the camshaft geared to the crankshaft in the ordinary way, but this intermediate shaft actuates a second shaft placed behind the cylinder head and operating parallel to the crankshaft. The air and the exhaust valves are so arranged that they can be easily removed and the piston is made of greater length so as to reduce the pressure and minimize the amount of wear between it and the cylinder walls. Details of lubrication of all bearings and other moving parts have been improved. The piston pin is lubricated through the hollow connecting rod.

In 1902, the writer arranged and introduced the oil engine for oil pipe line pumping service. A number of engines for this service were first installed for the Gulf Pipe Line Company in Texas and since then the installation of several hundred engines with many of the leading pipe line companies in the south or southwest territories has followed. These pumping stations consist of several units, some stations having as many as six engines. The capacity of each unit varies from 90 to 150 h.p. and is composed of the engine direct connected to a vertical or horizontal power pump. The former installations were equipped with friction clutch couplings between the engines and the pumps. In the later installations the connection used between engines and pumps is a flexible coupling or, in some cases, a rigid coupling. The pump is furnished with a by-pass between the suction and discharge so that, in starting the engine, the load is very much reduced. In the latest arrangement of this pumping unit the oil engine flywheel is placed close to the out-board bearing. In this way the main bearings are relieved of this weight and unequal wear on the bearings is avoided.

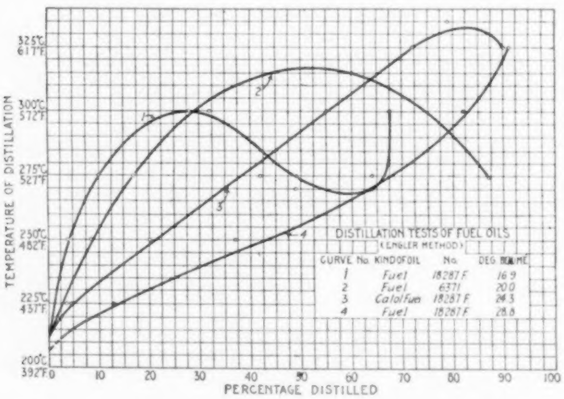


Fig. 22 Curves showing Distillation Tests of Fuels

This type of pumping outfit was fully described in a paper[1] before the Society by Forrest M. Towl, where it was stated the total efficiency of an 85-h.p. engine in three tests was 26.8, 27,75 and 27.52 per cent, respectively. The efficiency of pump and transmission was stated as 92.1 per cent. The fuel consumption per pump horsepower by displacement was 0.5171 lb. Tests were made with 33-deg. Beaumé fuel having a heat value of 19,059 B.t.u. per pound.

[1] Trans. A. S. M. E., vol. 33, page 905.

CALIFORNIA FUELS

The oil engine for pipe line service has not yet been used to any extent in the California oil fields. Table 4[1] shows the characteristics of California crude oils, while Fig. 22 gives results of distillation tests. It is necessary to heat such to a temperature that they will flow readily in the pipe lines and can be satisfactorily handled by the pump. The amount of heat necessary to raise the temperature of crude oil of 15-deg. Beaumé, assuming its specific heat to be 0.333 (which value seems to be difficult to exactly determine), is shown by the following remarks:

The amount of oil pumped per b.h.p-hr. at a pressure of 570 lb. is 135 gal., and the heat required to raise this quantity of oil through a range of 41 deg., or from a temperature of 69 deg. to 110 deg. fahr., would be 18,400 B.t.u. The amount of waste heat from an oil engine consuming half a pound of fuel per actual h.p-hr., both from the waste heat of the water jacket and that recoverable from the exhaust, with the most advantageous arrangement, is approximately 4200 B.t.u. Thus, taking this waste heat, it is evident that 14,200 B.t.u. per b.h.p. of the pumping outfit per hour would have to be furnished from an outside source to provide sufficient heat to raise the oil to the required temperature.

In a steam pumping plant this can be advantageously taken from the exhaust steam of the steam plant. The fuel consumption of the average steam pumping plant may be taken as 1.5 lb. of oil fuel per b.h.p-hr., but sufficient heat is in this case also available for heating the crude oil to the temperature above referred to.

With the oil engine plant, 0.5 lb. of fuel per b.h.p-hr. is required for the actual pumping process and from the figures above it will be seen that an amount of heating equivalent to that developed from a pound of oil would be necessary to heat the oil passing through the pipe line. Thus the total fuel consumption of the oil engine and that of the steam pump, allowing for heating, is approximately the same.

The oil engine outfit can operate with a poor quality of cooling water which would, however, be unsatisfactory for boiler use. This is a great advantage in favor of the former in many localities where only a poor quality of water can be procured.

Table 5[2] shows the costs of installation and operation of the different types of engines specified prevailing in California in 1914. The prices quoted for each fuel may not now be correct and the costs of fuel may require slight modification to conform with prevailing prices. The writer is informed that the price for 48 to 50-deg. Beaumé distillate is 6 cents per gal. in 110-gal. drums, while Diesel fuel oil is quoted at 85 cents per 42-gal. barrel in tank cars 25 miles north of San Francisco. Calol fuel oil 24-deg. Beaumé is 75 cents per 42 gal. and fuel oil not less than 14-deg. Beaumé is 60 cents per barrel in tank cars f.o.b. Richmond, Cal. The yearly fixed charge of 20 per cent is a higher rate than is usual to allow in the Eastern States where 5 per cent interest and 5 per cent depreciation are considered sufficient.

[1] Table 4 was partly compiled by Smith-Booth-Usher Co. and its insertion is due to their courtesy. Fig. 23 is shown by permission of the Standard Oil Co. of California.

[2] Table 5 was compiled by Messrs. Smith-Booth-Usher Co. in 1914. It is due to their courtesy that it is shown. Data regarding hot surface engine has been added.

THE STRENGTH OF GEAR TEETH

BY GUIDO H. MARX AND LAWRENCE E. CUTTER,
PALO ALTO, CAL.

Members of the Society

(SECOND PAPER)

THE investigations reported upon in this paper were undertaken for the purpose of supplementing those presented to the Society at its Annual Meeting of 1912, by the senior author.[1] The methods of conducting the tests, and of mathematical analysis employed in working up the results, were substantially the same as described in the earlier paper and are not repeated here. Paragraph references to the first paper will be used to direct attention to explanatory matter which is here omitted.

The limitations of the apparatus available for the earlier experiments made it impossible to secure positive data at pitch speeds exceeding 500 ft. per min., although significant data of a negative character were obtained at speeds up to 1000 ft. per min.[2]

In order to get positive data at high pitch speeds, an improved form of the apparatus used in the earlier experiments was devised[3] and connected by chain drive to a 50-h.p. motor capable of taking care of momentary overloads of 100 per cent. The main difference between the new apparatus and the old lay in the employment of Hess-Bright ball-bearings throughout in place of ordinary journal bearings. Each shaft was carried on two of these radial bearings, No. 307.

A second improvement was in the prony brake (Fig. 1). This was devised to be self-contained, the friction load due to scooping up the circulating cooling water being weighed on the scales with the rest of the friction load. It worked with great steadiness and proved eminently satisfactory. Owing to the high rim speeds reached, the brake wheel was carefully finished all over and had a web in place of arms.

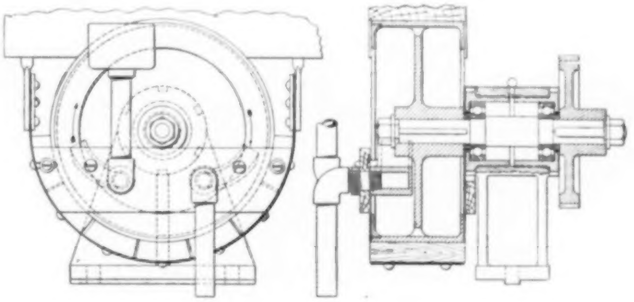


FIG. 1 PRONY BRAKE

A few holes drilled through the web at its outer circumference permitted the free circulation of the cooling water.

OUTLINE OF TESTS

The gears which were tested were made by The Brown & Sharpe Mfg. Co. and the Fellows Gear Shaper Co. The in-

[1] Trans. A. S. M. E., vol. 34, paper 1382, pp. 1323-1398.
[2] Trans. A.S.M.E., vol. 34, p. 1390.
[3] Par. 8 and 9, paper 1382.

ABSTRACT OF PREVIOUS PAPER ON THE STRENGTH OF GEAR TEETH, BY GUIDO H. MARX

The teeth of gear wheels when transmitting power are individually subjected to an action akin to that applied to a beam fixed at one end, with a load somewhere between the fixed and the free ends. All standard formulae or diagrams for the proportioning of such teeth therefor involve a factor representing the allowable unit fiber stress in a cantilever beam subjected to a bending moment.

The experiments described in this paper were undertaken with the primary purpose of throwing some light upon the question of this allowable unit fiber stress for modern cut cast-iron gear teeth under operating conditions, since definite data upon this point have been lacking, particularly with reference to the effect of pitch line velocity.

The formula for the safe equivalent load at pitch line as derived from these experiments is[1]:

$$W = \frac{spf}{k}\left(0.154 - \frac{1.26}{n}\right) va$$

in which

W = safe working load at pitch line in lb.
s = modulus of rupture = 39,000 in these tests, but ordinarily to be taken = 36,000
p = circular pitch in in.
f = width of face in in.
k = factor of safety
n = number of teeth in gear
v = velocity coefficient from take below
a = arc of action cofficient from table below

COEFFICIENTS BASED ON ARC OF ACTION

Ratio: Arc of Action / Pitch Arc	1	1.4	1.6	1.7	1.8	1.9	1.95	2.00
Corresponding a.....	1	1.05	1.1	1.15	1.24	1.38	1.47	1.60

VELOCITY COEFFICIENTS

Pitch velocity, ft. per min....	000	100	150	200	300	400	500
Ratio: Breaking Load at Given Vel. / Breaking Load at Zero Vel. (20-tooth pinions)	1.0	0.789	0.725	0.702	0.702	0.707	0.712
Ratio: Breaking Load at Given Vel. / Breaking Load at Zero Vel. (30- and 40-tooth gears)	1.0	0.819	0.792	0.768	0.726	0.743	0.770
v—Velocity coefficient, safe........	1.0	0.80	0.75	0.72	0.70	0.68	0.66

[1] Trans. A. S. M. E., vol. 34, paper 1382, pp. 1323-1398.

Presented at the Panama-Pacific Internationa Exposition meeting, San Francisco, September 1915, of THE AMERICAN SOCIETY OF MECANICAL ENGINEERS. The paper may be obtained in pamphlet form; price 10 cents to members, 20 cents to non-members. The previous paper by the senior author, No. 1382, may also be obtained in pamphlet form; price 25 cents to members, 50 cents to non-members.

vestigation divided itself into the following main divisions:

a Tests on 30T meshing with 40T, Brown & Sharpe $14\frac{1}{2}$-deg. involute, at pitch speeds from 500 to 2000 ft. per min. to determine velocity coefficients, *v*, to supplement those derived in the earlier experiments for speeds below 500 ft. per min.[1]

b Tests on 30T meshing with solid 60, 80, 100, and 150T Brown & Sharpe $14\frac{1}{2}$-deg. involute, to supplement earlier tests on effect of arc of action, to determine more fully arc of action influence.

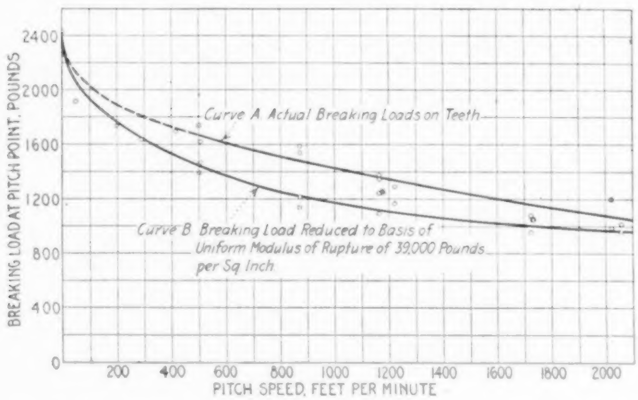


FIG. 2 RELATION BETWEEN PITCH SPEED AND BREAKING STRENGTH OF BROWN & SHARPE 30- AND 40-TOOTH $14\frac{1}{2}$-DEG. INVOLUTE GEARS

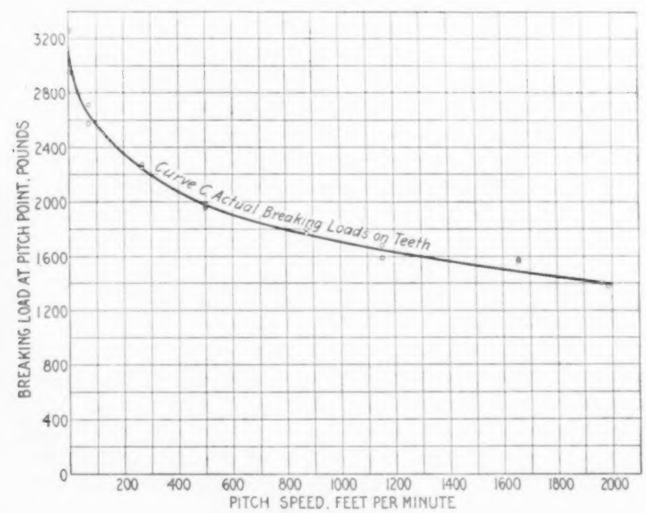


FIG. 3 RELATION BETWEEN PITCH SPEED AND BREAKING STRENGTH OF FELLOWS 30- AND 40-TOOTH 20-DEG. INVOLUTE STUB-TOOTH GEARS

c Tests on 30T meshing with 40T, Fellows 20-deg. involute stub-tooth, for speeds from zero to 2000 ft. per min. to determine velocity coefficients, *v*, for this form of tooth.

d Tests on 30T meshing with 20, 40, 60, 80, and 100T, Fellows 20-deg. involute solid gears, on effect of arc of action, to determine arc of action coefficients, *a*, for this type of gear.

e Static tests on Fellows gears to determine actual breaking strength of individual teeth, for determination of experimental values of factors for form of tooth as determined by the number of teeth in gear (Lewis's factor *y*). See Par. 28, paper 1382.

The Brown & Sharpe gears were of their standard 10 diametral pitch, $14\frac{1}{2}$-deg. involute form and those used in the tests involving the effect of pitch speed (Tests 1-12 inclusive) were sent from stock. These stock gears having a width of face of $1\frac{3}{16}$ in. were reduced by us to the width of $1\frac{1}{16}$ in. for which the apparatus had been constructed. The 30 and 60T gears were solid discs and the others were webbed, in order to eliminate the effect of weakness of arms and rims; the 80, 100 and 150T gears were made from patterns furnished by the authors. Solid grease lubricant liberally applied was used on all gears.

The Fellows gears were all of their $\frac{10}{12}$-pitch, 20-deg. involute form, and were solid discs in every case.

All gears when tested had the width of face of $1\frac{1}{16}$ in. The 20 and 30T gears (except the 30T gears of Tests 24A

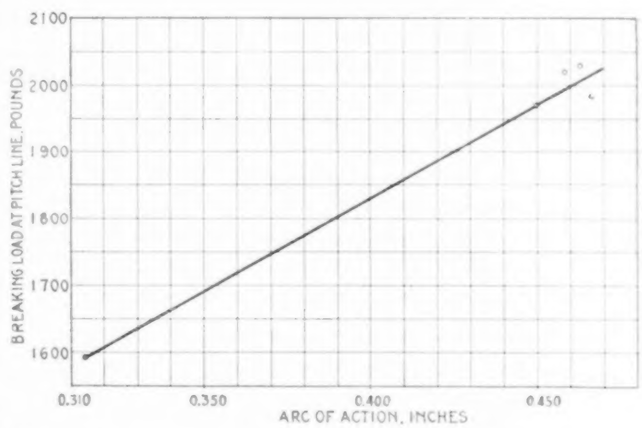


FIG. 4 RELATION OF BREAKING LOAD TO ARC OF ACTION: FELLOWS 20-DEG. INVOLUTE AT 500 FT. PER MIN. PITCH SPEED

and 25A) had a bore of $1\frac{1}{16}$ in., and all others had a bore of $1\frac{5}{16}$ in.

The material (cast-iron) was tested in all cases by means of specimens cut from the gears themselves[1] and the results are given in detail in an appendix. The gears of each manufacture were furnished in two separate installments. The material of the gears furnished for the tests on influence of arc of action (Tests 13-20 and 18A-23A inclusive) was stronger in both cases than that of the gears previously furnished for the tests on influence of pitch speed (Tests 1-12 and 1A-17A inclusive). Where the variation of the strength of material was such as to call for a correction in order to get consistent and comparable results, this was made; but in all cases the actual test results are given first.

SERIES A: TESTS TO DETERMINE VELOCITY COEFFICIENTS, BROWN & SHARPE GEARS

Table 3 of velocity coefficients, *v*, (Par. 21, paper 1382), for Brown & Sharpe $14\frac{1}{2}$-deg., cast-iron gears may be considered as quite definitely established for the entire range of speeds from zero to 2000 ft. per min. An explanation follows of the method by which these values were derived, from which it would appear to be safe to extrapolate beyond

[1] Par. 2, 7 and 21, paper 1382.

[1] Par. 22, paper 1382.

the speed of 2000 ft. per min., if desired,—safer than to make the tests. In fact, the authors are entirely willing to leave the conduct of all tests at higher pitch speeds to those who would like to see them made.

The data from which the values in Table 3 were derived are given in Tables 1 and 2 and in Fig. 2. Table 1 gives the results of the supplementary tests on the effect of speed on breaking strength of Brown & Sharpe 14½-deg. involute, $1^1/_{16}$-in. face, 30T meshing with 40T. The experiments previously reported[1] for gears of these sizes and this type gave results up to a pitch speed of 415 ft. per min. These results, together with those of Table 1, are plotted in Fig. 2, Curve *A*.

In Par. 14 to 17 of Paper 1382, attention was called to an apparent rise of strength at speeds above 300 ft. per min. and the tentative suggestion advanced that this might be due to passing a maximum percussive effect. The tests at the speeds above 500 ft. per min. failed to maintain this view. Moreover, the tests on the Fellows gears reported on in a later section of this paper showed no such phenomenon. In the latter case ball bearings were used throughout for the series of tests involving 30T and 40T gears. The explanation of the irregularity of the Brown & Sharpe curve (including the phenomenon of its rise) lies in the use of ordinary journal bearings in the first set of experiments. The friction of the brake shaft bearings was neglected. In the original paper it was assumed that the only effect of this is to make the computed breaking load of the teeth a very little less than its real value in each case.

A study of journal friction and variations of coefficients of friction with speed, made by the senior author in another connection, clears up this matter. Without entering into detail, the coefficient of friction of the journals used in the earlier apparatus is a variable, being greatest at zero velocity and decreasing to a minimum at about the rotative speed corresponding to the pitch speed of 415 ft. per min. At this speed the coefficient of friction (perfect film lubrication) is not widely different from the practically uniform coefficient of friction for ball bearings. Had this variable effect of friction not been neglected, the actual curves would probably not have shown this fall and subsequent rise.

If due allowance be made for this frictional resistance and it be properly added to the observed breaking load in each case, the actual curve for the entire range would be approximately that shown by the dotted line up to the speed of 500 ft. per min., and the full line from there on to 2000 ft. per min. (Curve *A*, Fig. 2). A correction was made for the added

[1] Par 15. paper 1382.

TABLE 1 EFFECT OF SPEED ON BREAKING STRENGTH

BROWN & SHARPE 14½-DEG. INVOLUTE, 10-PITCH, $1\frac{1}{16}$-IN. FACE, 30T MESHING WITH 40T; 1ST SERIES, 1914

Test number	Cast Iron Gears		8-Pitch B. & S. Steel Change Gears			
	Pitch speed, ft. per min.	Equivalent load at teeth, pounds	Number of teeth: Driver	Number of teeth: Driven	Pitch speed	Equivalent maximum pitch load
1	501	1743	100	70	1462	598
2	507	1622	100	70	1479	556
3	872	1441	100	40	1454	864
4	872	1592	100	40	1454	955
5	1221	1289	70	20	1018	1547[1]
6	1163	1380	100	30	1454	1104
7	1176	1259	100	30	1470	1007
8	1163	1350	100	30	1454	1080
9	1724	1078	100	20	1437	1293
10	1734	1047	100	20	1444	1257
11	2021	1199	120	20	1684	1438
12	2057	1017	120	20	1714	1221

[1]Steel gears abraded.

TABLE 2 REDUCTION OF BREAKING LOAD TO BASIS OF UNIFORM MODULUS OF RUPTURE OF 39,000 LB. PER SQ. IN.

BROWN & SHARPE GEARS

Test number	Actual Modulus of rupture from table Appendix 2	Conditions of Running Test				Equivalent breaking load for modulus of rupture of 39,000 lb. per sq. in.
		Teeth in C. I. driver	Teeth in C. I. driven	Actual breaking load at pitch line by test	Velocity at pitch line, ft. per min.	
1	48,770	30	40	1743	501	1394
2	42,976	30	40	1622	507	1471
3	46,323	30	40	1441	872	1213
4	54,632	30	40	1592	872	1137
5	43,143	30	40	1289	1221	1165
6	49,040	30	40	1380	1163	1097
7	39,288	30	40	1259	1176	1249
8	42,382	30	40	1350	1163	1243
9	43,868	30	40	1078	1724	958
10	38,779	30	40	1047	1734	1053
11	47,400	30	40	1199	2021	987
12	41,300	30	40	1017	2057	961
13	69,600	30	60	2372	501	1329
14	59,460	30	60	2271	504	1489
15	58,840	30	80	1930	507	1279
16	59,300	30	80	2044	504	1344
17	55,850	30	100	1817	510	1269
18	59,840	30	100	2059	507	1342
19	66,620	30	150	1998	507	1170
20	61,100	30	150	1917	507	1224

TABLE 3 VELOCITY COEFFICIENTS (v). BREAKING LOAD ON TEETH REDUCED TO BASIS OF UNIFORM MODULUS OF RUPTURE

BROWN & SHARPE 14½-DEG. INVOLUTE GEARS

Pitch velocity, ft. per min. . .	0000	100	200	300	400	500	600	700	800	900	1000	1100
Velocity coef., v .	1.000	0.795	0.730	0.675	0.635	0.595	0.565	0.540	0.520	0.500	0.485	0.470
Pitch velocity, ft. per min. . .	1200	1300	1400	1500	1600	1700	1800	1900	2000			
Velocity coef., v .	0.455	0.445	0.435	0.430	0.420	0.415	0.410	0.405	0.400			

TABLE 4 TESTS ON INFLUENCE OF ARC OF ACTION

Brown & Sharpe 14½-deg. Involute, 10-pitch Gears

Test number	Number of Teeth C. I. Test Gears		Pitch speed, ft. per min.	Equivalent breaking load at pitch line, pounds	Arc of action, inches[1]	Equivalent breaking load. Reduced to uniform modulus of rupture of 39,000 lb. per sq. in.
	Driver	Driven				
1	30	40	501	1743	0.628	1394
2	30	40	507	1622	0.628	1471
				Av. 1683		Av. 1433
13	30	60	501	2372	0.649	1329
14	30	60	504	2271	0.649	1489
				Av. 2322		Av. 1409
15	30	80	507	1930	0.662	1279
16	30	80	504	2044	0.662	1344
				Av. 1987		Av. 1312
17	30	100	510	1817	0.671	1269
18	30	100	507	2059	0.671	1342
				Av. 1938		Av. 1306
19	30	150	507	1998	0.685	1170
20	30	150	507	1917	0.685	1224
				Av. 1958		Av. 1197

[1]See Appendix No. 3, Paper 1382, for discussion of determination of arc of action.

TABLE 5 COEFFICIENTS BASED ON ARC OF ACTION

Brown & Sharpe, 14½-deg. Involute Gears

Ratio: $\frac{\text{Arc of action}}{\text{Pitch arc}}$	1	1.4	1.6	1.7	1.8	1.9	1.95	2.00	2.2
Corresponding a	1	1.05	1.1	1.15	1.24	1.38	1.47	1.60	1.60

TABLE 6 FELLOWS 20-DEG. INVOLUTE STUB-TOOTH GEARS, $^{10}/_{12}$ PITCH, 1 $\frac{1}{16}$-IN. FACE 30-TOOTH MESHING WITH 40-TOOTH

1st Series, 1914

Test number	Cast Iron Gears		8-Pitch, B. & S. Steel Change Gears			
	Pitch speed, ft. per min.	Equivalent load at teeth, lb.	No. of teeth		Pitch speed, ft. per min.	Equivalent maximum pitch load, lb.
			Driver	Driven		
13A	0	2953	....	....	....	....
14A	0	3256	....	....	....	....
1A	72	2575	20	100	301	618
2A	71	2711	20	100	297	651
3A	266	2273	30	40	444	1364
4A	266	2257	30	40	444	1354
5A	501	1955	100	70	1462	670
6A	501	1985	100	70	1462	681
7A	872	1804	100	40	1454	1082
8A	872	1773	100	40	1454	1064
9A	1149	1683	100	30	1437	1346
10A	1149	1592	100	30	1437	1274
11A	1654	1577	100	20	1378	1892[1]
12A	1654	1562	100	20	1378	1874
16A	1960	1403	120	20	1633	1683
17A	1984	1380	120	20	1654	1656

[1]Log of test says, "The steel 20T showed about the limit of its endurance without abrasion."

TABLE 7 VELOCITY COEFFICIENTS (v), BASED ON ACTUAL BREAKING LOAD ON TEETH

Fellows 20-deg. Involute, Stub Tooth Gears

Pitch velocity, ft. per min.	0000	100	200	300	400	500	600	700	800	900	1000
Velocity coefficient, v . .	1.000	0.825	0.755	0.705	0.665	0.635	0.615	0.595	0.580	0.565	0.550
Pitch velocity, ft. per min.	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	
Velocity coefficient, v . .	0.540	0.525	0.515	0.505	0.495	0.485	0.475	0.470	0.460	0.450	

load on the gear due to journal friction for the test at zero velocity, assuming a value of 0.20 for the static coefficient of friction, giving as a result an added load of 175 lb. on the tooth, thus bringing the average value up to 2435 lb. for zero velocity. It is on the side of safety to base the coefficient of velocity, v, on this value.

The stock gears used in Tests 1 to 12 showed a wide variation in material as indicated by flexure tests. Since the material of the similar gears reported upon in Paper 1382 had a very uniform modulus of rupture of about 39,000 lb. per sq. in., it would seem better to reduce the actual results of the present experiments to a basis of a uniform modulus of rupture of 39,000 if the two sets of observations are to be combined. This has been done in the last column of Table 2. Fig. 2, Curve B, shows the results graphically. An explanation of this variation of strength probably lies in the reduction of the width of face of these gears after their receipt by us. The removal of one-eighth of an inch at one surface or the other would have a marked effect, since the surface material is recognized as being the stronger. If this material were removed on the side which originally had had the greater depth of cut taken from it in finishing the gear blank, the result would be different from that if the reduction in width had been made on the other surface.

Objection may be made to using Curve B rather than Curve A for the determination of the velocity coefficients. It is to be noted, however, that this reduction, made for the purpose of having the present and earlier experiments more justly comparable, also makes the present test results more consistent and it gives velocity coefficients which, being lower than those which would be derived from Curve A, are on the side of additional safety.

Series B: Tests to Determine Influence of Arc of Action, Brown & Sharpe Gears

The experiments under this head were originally planned (when the gears for the series were ordered) to supplement those on the influence of arc of action, described in Par. 32, paper 1382, and shown there in Fig. 9, Curve B; but subsequently it was decided to run the tests independently of the previous ones, at a pitch speed of approximately 500 ft. per min., in order to make them comparable with the Fellows tests, Nos. 5A, 6A, 18A, to 23A inclusive, described later in the present paper, which had already been made at this speed. Table 4 gives the results.

The unusually high modulus of rupture shown by the material of most of the gears used in this set of tests, made it seem desirable to adopt the expedient of reducing the actual

test results to a basis of an imaginary uniform material having a modulus of rupture of 39,000 lb. per sq. in.

It is impossible, however, to get any satisfactory light out of this series of tests on the actual influence of the arc of action. While the unmodified results, with the exception of Tests 13 and 14, are not incompatible with those obtained in the earlier paper, when reduced to a basis of a uniform modulus of rupture they show an apparent falling off of breaking strength with increase of arc of action for ratios of arc of action to pitch arc greater than 2. This may actually be the case, but it is contrary to the effect of ratio of arc of action to pitch arc for values ranging from 1 to 2 and does not seem rational. It is also contrary to the results given in Tables 10-14, paper 1382.

It must be borne in mind that reducing the tests to a uniform modulus of rupture on the basis of a test bar cut from the gear is only a crude expedient adopted in default of a better. Cast iron is too variable a material to permit certainty that the strength at the tooth which first yielded was just that of the test bar. In addition, we have the fact that the teeth do not fail by pure flexure and that, therefore, using the modulus of rupture for flexure as the unifying basis is open to some question. But it is equally evident that material which showed as much variation as did this calls for the reduction of test results to some kind of comparable basis.

Thinking that the discrepancy of the results might be due to the possible failure of the teeth of the larger gear rather than the smaller, owing to the chance of weaker material in the larger gears, test bars were cut from the 60T and 80T gears of Tests 13 and 15. While the material proved to be a little weaker than that of the corresponding 30T pinions, computations showed that this was more than compensated for by the stronger form of the teeth of the larger gears. This possible explanation of the discrepant results also had to be abandoned.

Another explanation of the reduced results running in the wrong direction may lie in the possibility that the shafts were not exactly parallel. This would cause severer stress conditions the larger the radius of the gear.

Weighing all the evidence, we consider that the arc of action coefficients, *a*, derived in the earlier paper from experiments on more uniform and normal material, are essentially correct and they are repeated here in Table 5, being extended to a ratio of

$$\frac{\textit{arc of action}}{\textit{pitch arc}} = 2.2$$

From the way an additional tooth comes into action, as shown by the imperceptible increase

TABLE 8 REDUCTION OF BREAKING LOAD TO BASIS OF UNIFORM MODULUS OF RUPTURE OF 39,000 LB. PER SQ. IN.

Fellows 20-deg. Involute Gears

Test number	Actual modulus of rupture from table Appendix 2	Conditions of Running Test				Equivalent breaking load for modulus of rupture of 39,000 lb. per sq. in.
		Teeth in C. I. driver gear	Teeth in C. I. driven gear	Actual breaking load at pitch line by test	Velocity at pitch line, ft. per min.	
1A	40,420	30	40	2575	72	2485
2A	38,977	30	40	2711	71	2713
3A	42,415	30	40	2273	266	2089
4A	36,403	30	40	2257	266	2418
5A	35,920	30	40	1955	501	2123
6A	39,250	30	40	1985	501	1972
7A	39,450	30	40	1804	872	1783
8A	39,771	30	40	1773	872	1739
9A	36,890	30	40	1683	1149	1779
10A	Not tested	30	40	1592	1149	Blow hole
11A	39,262	30	40	1577	1654	1567
12A	38,240	30	40	1562	1654	1593
13A[1]	44,480	30	40	2953	0000	2589
14A	44,480	30	40	3256	0000	2855
15A	44,480	30	40	3861[2]	0000	Void
16A	43,897	30	40	1403	1960	1247
17A	38,850	30	40	1380	1984	1386
18A	46,030	30	80	1643	507	1392[3]
19A	46,900	30	80	2029	507	1688
20A	45,310	30	100	1907	507	1642
21A	46,460	30	100	2059	507	1729
22A	44,190	30	60	1969	507	1738
23A	44,860	30	60	2070	507	1800
24A	....	20	30	1477	476	....
25A	....	20	30	1437	476	....

[1]Same gears used in tests 13A, 14A and 15A.
[2]Void. Not weakest position.
[3]Void. See log of test.

TABLE 9 ARCS OF ACTION

Combinations of $^{10}/_{12}$ Pitch Gears Fellows 20-deg. Involute

Gear Teeth		Arc of action, inches	Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$
Driver	Driven		
Single tooth engagement	Weakest position[1]	0.31416	1.0000
12	12	0.38760	1.2334
20	30	0.43109	1.3722
30	40	0.45008	1.4327
30	60	0.45844	1.4591
30	80	0.46319	1.4744
30	100	0.46643	1.4852
30	Rack	0.48075	1.5271
100	100	0.48996	1.5596
100	Rack	0.50427	1.6051

[1]Position A, Table 8, Paper 1382.

TABLE 10 INFLUENCE OF ARC OF ACTION

Fellows 20-deg. Involute Gears

STATIC TESTS

Test number	Conditions of test	Breaking load at pitch line, pounds	Arc of action, inches	Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$
1B	30 T, position "A"........	2536	0.31416	1.0000
2B	30 T, position "A"........	2475	0.31416	1.0000
		Av. 2506	0.31416	1.0000
13A	30 T, driving 40 T.........	2953	0.45008	1.4327
14A	30 T, driving 40 T.........	3256	0.45008	1.4327
		Av. 3105	0.45008	1.4327

TABLE 11 INFLUENCE OF ARC OF ACTION AT APPROXIMATELY 500 FT. PER MIN., PITCH SPEED

FELLOWS 20-DEG. INVOLUTE GEARS

Test number	Gear Teeth: Driver	Gear Teeth: Driven	Pitch speed ft. per min.	Breaking load at pitch line, pounds	Arc of action, inches	Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$
5A	30	40	501	1955	0.45008	1.4327
6A	30	40	501	1985	0.45008	1.4327
				Av. 1970	0.45008	1.4327
22A	30	60	507	1969	0.45844	1.4590
23A	30	60	507	2070	0.45844	1.4590
				Av. 2020	0.45844	1.4590
19A	30	80	507	2029	0.46319	1.4744
				Av. 2029	0.46319	1.4744
20A	30	100	507	1907	0.46643	1.4852
21A	30	100	507	2059	0.46643	1.4852
				Av. 1983	0.46643	1.4852

TABLE 12 COEFFICIENTS (a), BASED ON ARC OF ACTION

FELLOWS 20-DEG. INVOLUTE, STUB TOOTH GEARS

Teeth in Engaging Gears		Ratio of $\frac{\text{arc of action}}{\text{pitch arc}}$	Corresponding a
Single tooth engagement		1.0000	1.00
12	12	1.2334	1.13
20	30	1.3722	1.20
30	40	1.4327	1.24
30	60	1.4591	1.25
30	80	1.4744	1.26
30	100	1.4852	1.27
30	Rack	1.5271	1.29
100	100	1.5596	1.31
100	Rack	1.6051	1.33

TABLE 13 EQUIVALENT STATIC BREAKING LOADS (W), AT PITCH LINE

FELLOWS 20-DEG. INVOLUTE, STUB TOOTH, $^{10}/_{12}$ PITCH GEARS

POSITION OF STRESSED TOOTH

Teeth in gear	Test number	Equivalent breaking load, W, pounds	Average W, pounds	$y = \frac{W}{s\,p\,f}$ ($s\,p\,f = 13{,}656$)
20	3B	1702		
20	4B	1762	1732	0.127
30	1B	2526		
30	2B	2486	2506	0.184
40	5B	3029	3029	0.222
60	7B	3582		
60	8B	3481	3532	0.259
80	9B	3443		
80	10B	3858		
80	11B	3631	3643	0.267
100	12B	3803	3803	0.279

of a for the range from a ratio of 1 to a ratio of 1.4, it is probable that the value of a remains at about 1.6 from a ratio of 2 to a ratio of 2.4.

The gears employed in Tests 13 to 20 inclusive were made from special patterns sent to the manufacturers. All of them were solid or webbed and the hubs were lengthened to permit a $2\frac{1}{2}$-in. key being used; this precaution being necessary because of the longer lever arm of the tooth load.

It was intended to carry out tests on the static strength of the individual teeth of these gears, as shown in position A, Table 8, paper 1382, but because of the exceptional strength of the material, which caused the shaft to spring, it was not certain that the teeth were being held in the proper relation at the instant of rupture and this purpose was abandoned. The experimental value of the factor for form of tooth (Lewis's factor y), as determined in Par. 29 and Appendix 4, paper 1382, is therefore retained, being—for the Brown & Sharpe $14\frac{1}{2}$-deg. involute teeth—equal to

$$\left(0.154 - \frac{1.26}{n}\right)$$

where n is the number of teeth in the gear.

SERIES C: TESTS TO DETERMINE VELOCITY COEFFICIENTS, FELLOWS GEARS

The tests for effect of pitch velocity on the breaking strength of Fellows 20-deg. involute, stub-tooth gears, $^{10}/_{12}$-pitch, $1^{1}/_{16}$-in. face, 30T meshing with 40T, gave remarkably uniform and consistent results. These are tabulated in Table 6 and shown graphically in Fig. 3. This uniformity is in a large measure due to the uniformity of the material of this set of gears, but may also have been influenced by the method of cutting. We had no apparatus to measure accuracy of tooth spacing and made no attempt to do so.

From the curve of Fig. 3, Table 7 of velocity coefficients, v, for Fellows 20-deg. involute gears has been computed. It will be noted that these values of v correspond quite closely to those obtained in the experiments with the Brown & Sharpe gears. (Compare Table 3.)

In the case of the Fellows tests the expedient of plotting the breaking loads reduced to a uniform modulus of rupture, and basing the velocity coefficients upon this curve, was not resorted to, as it was in the case of the Brown & Sharpe tests. The material of the gears used in this set of tests, 1A to 17A inclusive, being from a single melt, showed only moderate variation in the flexure tests and had an average modulus of rupture of 39,600 lb. per sq. in. For this reason, and for the further reason that the velocity coefficients derived from the reduced curve would be slightly higher than those derived from the actual test results and therefore

tend away from safety rather than toward it, no curve is drawn in Fig. 3 reducing the actual test results to a uniform basis of a modulus of rupture of 39,000 lb. per sq. in. Table 8, however, gives the results of reduction computations in the same manner as shown in Table 2 for the Brown & Sharpe gears and is included here to complete the record. If the modified results be plotted it will be noted that they are not as regular and consistent as the actual test results.

SERIES D: TESTS TO DETERMINE ARC OF ACTION COEFFICIENTS, FELLOWS GEARS

The shortened addendum used in the Fellows system makes for shorter and less varied arcs of action. By the method described fully in Appendix 3 of paper 1382, the values of the arcs of action for various combinations of Fellows gears were computed. The results are given in Table 9.

Tables 10 and 11 give the results of those experiments which were made to determine the effect of arc of action on breaking strength in the case of the Fellows gears. From Table 10 it is seen that in the static tests there is an increase in strength in the ratio of $^{3108}/_{2506} = 1.24$ for an increase in arcs of action in the ratio of

$$\frac{0.45008}{0.31416} = 1.4327$$

Taking account of the single tooth, weakest position, static strength of the 30T gear 2506 lb. as shown by the average of Tests 1B and 2B, and multiplying by the velocity coefficient 0.635 for 500 ft. per min., we get 1591 lb. as the breaking strength at this speed for a 30T Fellows gear with an arc of action of 0.31416.[1] This point is plotted in Fig. 4 with the averages of Table 11, which therefore shows the relations between equivalent breaking load and arc of action for the Fellows gears at this speed.

[1] Par. 32, paper 1382.

An interesting check is to compare with the results of Table 10, the increase for strength at this speed of 500 ft. per min., for an increase of arc of action from 0.31416 to 0.45008. The ratio of increase of strength is $^{1970}/_{1591} = 1.24$, as before.

Objection may be made to there being too few points to locate the curve of Fig. 4 with reasonable accuracy. As seen in the next paragraph the matter is not vital. The variation in value of the arc of action coefficient, a, in all cases except those involving very small pinions, is so slight that no appreciable error is introduced if it be taken as uniformly equal to 1.25 in the case of the Fellows gears.

Table 12 gives values for the arc of action coefficient,[2] a, as deduced from Fig. 4 for the gear combinations of Table 9 as covering the ordinary range. The values for others can be computed readily or interpolated with sufficient accuracy. It can be seen that $a = 1.33$ is about the maximum value in any practical case as compared with a corresponding maximum of about 1.60 for the Brown & Sharpe system.

TABLE 14 SUMMARY OF INVESTIGATION OF BREAKING STRENGTH OF BROWN & SHARPE 14½-DEG. INVOLUTE, AND FELLOWS 20-DEG. INVOLUTE, STUB-TOOTH, CAST-IRON, CUT GEARS

SYMBOLS, BOTH SYSTEMS

W = safe equivalent load at pitch line, pounds
s = modulus of rupture = 36,000 lb. per sq. in. for cast iron
p = circular pitch, inches = pitch arc
f = width of face of gear, inches
n = number of teeth in gear
k = factor of safety
Suggested values: k = 4, for steady load, no reversal of stress
k = 6, suddenly applied load, no reversal of stress
k = 8, suddenly applied load, with reversal of stress
r = velocity coefficient. See tables
a = arc of action coefficient. See tables

FORMULÆ

Brown & Sharpe 14½-deg. involute:

$$W = \frac{s\,p\,f}{k}\left(0.154 - \frac{1.26}{n}\right) r\,a$$

Fellows 20-deg. involute, stub tooth:

$$W = \frac{s\,p\,f}{k}\left(0.278 - \frac{2.69}{n}\right) r\,a$$

Neither formula holds for values of n less than 12.

VALUES OF (r) — VALUES OF (a)

Pitch velocity, ft./min.	r: Brown & Sharpe 14½-deg. involute	r: Fellows 20-deg. involute stub tooth	Pitch velocity, ft./min.	r: Brown & Sharpe 14½-deg. involute	r: Fellows 20-deg. involute stub tooth	Teeth in engaging gears		Corresponding a: Brown & Sharpe 14½-deg. involute	Corresponding a: Fellows 20 deg involute stub tooth
0000	1.000	1.000	1100	0.470	0.540	Single tooth engages		1.00	1.00
100	0.795	0.825	1200	0.455	0.525	12	12	1.10	1.13
200	0.730	0.755	1300	0.445	0.515	20	30	1.15	1.20
300	0.675	0.705	1400	0.435	0.505	30	30	1.47	1.22
400	0.635	0.665	1500	0.430	0.495	30	40	1.60	1.24
500	0.595	0.635	1600	0.420	0.485	30	60	1.60	1.25
600	0.565	0.615	1700	0.415	0.475	30	80	1.60	1.26
700	0.540	0.595	1800	0.410	0.470	30	100	1.60	1.27
800	0.520	0.580	1900	0.405	0.460	30	Rack	1.60	1.29
900	0.500	0.565	2000	0.400	0.450	100	100	1.60	1.31
1000	0.485	0.550	....	....	....	100	Rack	1.60	1.33

SERIES E: DETERMINATION OF VALUE OF FACTOR Y, LEWIS FORMULA

The next step in the investigation of the Fellows gears was the determination of the expression for the factor depending upon the change of tooth-form as dictated by the number of teeth in the gear. This is Mr. Lewis's well-known factor y. For a 20-deg. involute tooth with addendum equal to 0.8 ÷ diametral pitch, Mr. Flanders[3] gives values from which we obtain

$$y = \left(0.173 - \frac{0.720}{n}\right)$$

By laying out the form of the 12, 30, 40 and rack teeth of

[2] Par. 33, paper 1382.
[3] Trans. A. S. M. E., vol. 30, p. 930.

the actual Fellows $^{10}/_{12}$-pitch, ten times full size, and employing the method described in Appendix 2, paper 1382, we obtained

$$y = \left(0.169 - \frac{0.972}{n}\right)$$

As was found in regard to the similar factor for the Brown & Sharpe system[1] this method, based upon an unmodified flexure theory, does not correspond to actual conditions. The teeth in every case show much greater breaking strength than either of these values of y would give when substituted in the single tooth static strength formula, $W = spfy$.

A series of tests was made on the static strength of single teeth under conditions of load application corresponding to engagement at their weakest position. This is Position A

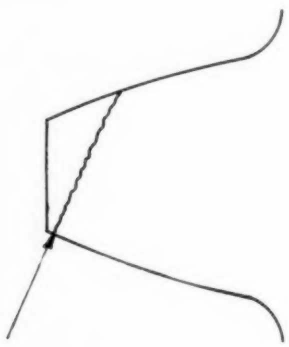


FIG. 5 MANNER OF TOOTH FAILURE

of Table 8, paper 1382, and corresponds to the maximum strength of such gears when the arc of action is just equal to or is less than the pitch arc (i.e., circular pitch). In this case both velocity coefficient and arc of action coefficient become equal to unity and the value of y can be computed directly. The loads were applied by means of a steel pinion. Par. 27, paper 1382. The results of these tests are given in Table 13. In computing the values of y, s is taken equal to the average shown by all the Fellows test specimens, 40,910 lb., $p = 0.31416$ in.; and $f = 1.0625$ in.

By the method of Appendix 4, paper 1382, these results give approximately a value of

$$y = \left(0.317 - \frac{3.81}{n}\right)$$

But an examination of this equation shows that it would lead to a zero value of y, and hence of W, for $n = 12$, which is obviously incorrect. It would also lead to a value of $W = 4329$ for a rack tooth ($n = \infty$); while the experiments showed that the teeth would fail by shear, as indicated in Fig. 5, rather than by flexure, long before such a load could be reached. A note made in the log at the time of these tests says: "It seems a fair conclusion that these stub-teeth when loaded at the end are apt to fail by shear before reaching a load that would break them out, in the case of 60T gears and larger." Our judgment based upon observed experiments was that this limiting value for a rack tooth end load would be 3800 lb. Upon this basis and by combination with W for $n = 20$, 30 and 40,

$$y = \left(0.278 - \frac{2.69}{n}\right)$$

was deduced. The results derived from its use checked very closely with the actual running test results. Where they depart from the test results in the static cases they do so on the safe side.

It is to be borne in mind that we questioned the test results in these static tests above 40T gears, as we noted in the log that because of the torsional deflection of the shafts we could not be certain that the teeth were in position A at the instant of rupture. Any deflection would put them in a position to carry a heavier load.

In the Fellows system of tooth forms the ratio of addendum to pitch is not a constant one for different pitches, hence the results obtained on $^{10}/_{12}$-pitch gears do not hold with exactness for other pitches. However, the differences in tooth proportions are not sufficiently great to forbid the use of these results with a reasonably close degree of accuracy for other pitches.

CONCLUSIONS FROM ENTIRE SERIES OF TESTS

For convenient reference the conclusions arrived at from the entire experimentation, reported upon in both this paper and No. 1382, are summarized in Table 14. The formulae and factors represent the best judgment of the present writers, based upon painstaking and unprejudiced study of the complete data. The original goal of the investigation, namely the definite determination of the effect of pitch-speed upon breaking strength, has been attained, we feel, for the ordinary working range of velocities.

Too much stress must not be laid upon the comparison, in individual cases, of the formula results and the test results reduced to the modulus of 36,000. In the non-homogeneous material, like cast-iron, the chances are altogether against the strength of the single test-specimen being exactly that of the tooth which first broke in the gear test. This is borne out by the fact that the actual test value of W sometimes comes out larger in the case of duplicate experiments (all

TABLE 15 CHECK OF FELLOWS FORMULA

Test number	W, by test	W, by formula $s = 39,588$
1A	2575	2622
2A	2711	2629
3A	2273	2225
4A	2257	2225
5A	1955	1957
6A	1985	1957
7A	1804	1753
8A	1773	1753
9A	1683	1642
10A	1592	1642
11A	1577	1480
12A	1562	1480
13A	2953	3081
14A	3256	3081
15A	Void	....
16A	1403	1399
17A	1380	1393

[1] Par. 29, paper 1382.

conditions the same) for the gear whose material subsequently showed the lower modulus of rupture in the flexure tests. (Examples: Tests 1A and 2A, 3A and 4A.) Again, in many duplicate tests where the differences in breaking strength lay in the same direction as the differences in test-specimen moduli, the tooth strength variation was not as great as the variation in modulus. Examples:

Tests 1 and 2; Ratio of Moduli, 1.135; Ratio of W, 1.075
Tests 4 and 3; Ratio of Moduli, 1.179; Ratio of W, 1.105
Tests 6 and 8; Ratio of Moduli, 1.157; Ratio of W, 1.022
Tests 9 and 10; Ratio of Moduli, 1.131; Ratio of W, 1.029

To get a better check of the formula, therefore, we may select Tests 1A-17A, inclusive, of the Fellows gears which were made from a single melt whose average modulus of rupture was 39,588 lb., substitute this value of s in the formula, and compare with the actual breaking test results. This is done in Table 15.

COMMENTS ON TESTS

The method of testing these gears was employed after due consideration, despite the criticisms made upon it in the discussion of the previous paper. It has the great merit of being both simple and positive. The apparatus is relatively inexpensive and requires no calibration. Since the chief criticisms were directed against the power consumption, meter readings were kept for the entire series of runs. The total power consumption as shown by the recording meter was only 150 kw-hr. The power cost is therefore inappreciable. Were these experiments on wear or endurance, rather than breaking strength, the cost of the power might enter into the problem as a determining factor and indicate the necessity for some such apparatus as that described by Wilfred Lewis at the June, 1914, meeting of the Society[1] However, with rupture tests, judging from our experience with the way the teeth are thrown at high speeds, it would seem inevitable that fractured cast-iron teeth would fall between the teeth of the steel gear and pinion and wreck the Lewis machine. It is also a question whether the steel gears (unless made of special material and heat-treated), necessarily having the same pitch and pitch-speeds as the cast-iron test gear, would be able to stand up without destructive abrasion under the load which would be required to break the cast-iron teeth. Our own experience (Tests 5 and 11A) leads us to doubt that ordinary, unhardened, steel gears would stand up under these conditions. To carry out our static tooth strength tests, where the load was directly applied by 10-pitch steel pinions, we found it necessary to case-harden these steel pinions.

These experiments, incidentally, give data on the carrying power shown by soft steel gears of the $14\frac{1}{2}$-deg. involute form, 8-pitch, $1\frac{1}{16}$-in. face, at pitch speeds ranging up to 1700 ft. per min. (See Tables 1 and 6.) Under the conditions of lubrication here employed the limiting load seems, roughly, to be about 1500 lb. per in. width of face for these gears.

In respect to the ball bearings in the improved testing apparatus, some light is thrown indirectly upon the carrying power of such bearings under rather severe conditions; for it must be borne in mind that the bearings were running, at the instant of rupture, in some cases at as high a rotative speed as 2500 r.p.m. and that the actual suddenly applied stress upon them, after the teeth began to break and wedge, must have been much greater even than the recorded breaking strength of the teeth, high as this was.

The tests were made in the laboratories of the Leland Stanford Junior University and the writers wish to express their appreciation of the cordial coöperation of the university authorities. Particular thanks are due Prof. W. F. Durand, executive head of the department of mechanical engineering, and to Prof. W. R. Eckart, in charge of the experimental engineering laboratories. Both the Brown & Sharpe Manufacturing Company and the Fellows Gear Shaper Company generously donated the gears necessary for the experiments.

[1] Trans. A. S. M. E., vol. 36, p. 231.

CORRESPONDENCE FROM MEMBERS OF THE SOCIETY

Provisions have been made by the Publication Committee for Correspondence Departments in The Journal as follows: A Department for contributed discussions on papers previously published, or new matter. A Members' Correspondence department including suggestions on Society affairs.

Contributions for these departments are earnestly solicited.

ON MEASURING GAS WEIGHTS

To the Editor:

Mr. Butterfield, in his paper on Measuring Gas Weights (The Journal, August, 1915), is to be commended in his desire to have weight of gas, as well as of air, as a standard. However, it is greatly to be doubted if the universal custom in this connection of always using cubic feet, can ever be superseded. I have made several attempts in this direction, but have found the effort so unpopular that it had to be abandoned. I, therefore, recommend the following as being the nearest practical attainment of Mr. Butterfield's idea.

Amounts of air or gas delivered by fans, blowers, centrifugal or reciprocating compressors, should be given as cubic feet, referred to a fixed pressure and temperature. I have used 14.7 lb. per sq. in. abs. (at sea level and 45 deg. north latitude, if such precision is needed) and 60 deg. fahr. temperature and have called the quantities so given "cu. ft. of standard air," or "standard gas." 70 deg. and 62 deg. have also been used. It would be desirable if a single temperature could be agreed on.

A cubic foot of standard air or standard gas is a unit of weight just as Mr. Butterfield suggests, but does not involve a serious departure from customary practice. Another definite unit, which is not a unit of weight but which must be kept in mind, is a cubic foot at atmospheric conditions. The weight of such a unit varies with barometer, altitude and atmospheric temperature. The unit most interesting to a designer of a fan or compressor is the cubic foot at the average atmospheric conditions of the point of installation, and this is usually to be understood when cubic feet of a fan, etc., is specified without qualification. The term "cu. ft. of free air" or "free gas" is often used without statement as to whether cubic foot of standard air or cubic foot of air at average atmospheric conditions is meant. Hence, the use of this term without definition should be avoided.

Sanford A. Moss.

Lynn, Mass.

OPPORTUNITY FOR THE ENGINEER IN CHINA

To the Editor:

There are, undoubtedly, many members of the Society who are engaged in business which, under certain conditions, would find a great and remunerative field in the Orient and especially in China. There are many, too, who have never given the matter any serious consideration. To such and all it will pay to turn attention China-ward for a little while and take note of the fast and favorably changing conditions there.

There seems to be considerable interest in Chinese business circles, just now, in the development of China's great, natural resources and their utilization in manufacturing and agriculture. Many inquiries are going about as to the cost of installing and running plants in a variety of manufacturing lines. While these may not materialize into large orders at once, on account of the high rate of exchange against China just now, and from other causes, still it shows a strong movement in the right direction of a tide which, if taken advantage of soon, should lead to good results to all parties concerned, but if neglected can never be regained.

There are several causes which have tended to stimulate this movement:

a. The European war has cut off China's facilities for borrowing and thrown her back on her own resources for raising funds; this was a good thing for China as it emphasized the value and importance of her rich assets and led many to look for means for using them.

b. The attitude of a neighboring nation which formerly supplied many manufactured articles to China has stirred up a strong feeling of revulsion which has started up a boycott all over the country, that is not an ordinary boycott, for there does not seem to be any official organization, but rather a spontaneous action which has been an impetus to supply, by home manufacture, as many of the things as possible that formerly were obtained from that country.

c. The ever increasing number of foreign educated men realize the value of China's resources and are seeking to introduce, to develop them, methods which they have learned of or seen abroad; this is becoming a stronger factor every year, especially in the case of the men returning from the United States.

It is coming to be recognized by Chinese business men that Chinese capital combined with the technical skill and knowledge of America and other advanced countries is what is needed here. As soon as financial conditions are favorable they will be ready to start operations; in the meantime they are gathering facts and figures as much as possible to be ready at the psychological moment. Why should not American manufacturers and machine builders be as astute and far sighted as these Chinese only recently awakened to our civilization?

Although the enterprises that are contemplated may be financed by Chinese capital or a combination of Chinese and American, there will, naturally, be a great opening for American machinery and manufactured goods of many kinds. Many new wants will be created by the new outlook and improved conditions.

In order to get this trade it is very desirable that as many American firms as possible get well represented here so that each nationality may get well acquainted and familiar before they begin to place orders. If the matter is delayed until the tide begins to turn it will be too late to get the proper benefits because it takes considerable time to get a good footing in such a market. Other nations, keen for the market, have been long established here but are more or less handicapped by the European war.

American goods and methods of business are much appreciated and more of the former would meet with favor if they were only here. Every student who returns from the United States has a soft spot in his heart for that country and its institutions. They form a large part of the foreign educated men. A large percentage of them get into influential places in business or the government and do not forget the good things they saw and learned abroad. Their number increases yearly.

As an aid in promoting trade between America and China, a Sino-American Bank is about to be established with sound backing in both countries. The preliminaries have already been settled by the recent Commercial Commission to America. New steamship lines are about to be organized through the same agencies.

American firms represented by Americans are not very numerous in this field yet but a few new ones are beginning to appear, here and there, which is an encouraging sign. It is the height of folly to let American firms be represented here by some other foreign nationality. That course has been taken by some but, to the resident here, the folly is apparent.

Although certain lines of American machine makers are very busy with orders in connection with the war, all those who can do so should turn their attention to the Chinese market, for a while at least, until a good foothold is established. Those who are well established here in the next year or two will have a prodigious advantage over the later comers and would be well repaid for their forethought. The Chinese are keen and reliable business people, are wide awake to the situation and will appreciate any sincere effort to boost things along here.

What would seem like a good proposition for some industries would be for several firms in allied lines to get together and establish a depot for their goods with a fairly good stock on hand for prompt delivery. The ability to show the goods and demonstrate the machinery will go a great way toward filling the order book. What is necessary is to get the goods in the front window where everybody can see them. The country best prepared for eventualities will win out in this race. *It is for Americans to decide whether they will let this opportunity slip through their hands or not.*

In some cases it might be well to arrange with Chinese capitalists to start branch works of American concerns with skilled American technicians in control of the producing side of the business, using such methods and appliances as seem best suited to the conditions here. The materials are here, good mechanics are here and the ready market. This is a field worth investigating. The Chinese are about one fourth of the world's population!

Trusting that this is of interest as coming from one in the field who has the interests of the United States and its industries at heart, I remain,

Sincerely yours,

Frank A. Foster.

Tientsin, China.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

"In modern German plants for the preparation of powdered coal for firing furnaces, the following is the accepted fundamental principle: simplicity of machinery and apparatus used and accessibility of the whole arrangement. In this respect the German construction differs materially from the American, and even though some typically American crushers, such as the Fuller-Lehigh system, have been adopted in some German plants, as a rule they have not found ready application in that country and for the same reason, the high speed machinery of this type built in Germany itself, has not been much used."

The above is a quotation from an abstract of an article in the important German periodical, *Stahl und Eisen,* an organ of the German Association of Metallurgists. In the common struggle for markets in which it is hoped the American industries will try to get the share to which the resources of the country and genius of its engineers entitle it, it will be of great value to engineers to know the operating conditions and perhaps even the idiosyncrasies of foreign markets.

This Month's Articles

In the section, Firing, is reported an article on the preparation of powdered coal and its firing in Germany, describing mainly the so-called Polysius system, viz., a crusher and grinder, the two combined, driving drums and layout of an ideal powdered coal fired plant.

In the section, Internal Combustion Engineering, is reported in brief an interesting investigation on the process of combustion occurring in a hot bulb engine.

Under Steam Engineering are given some data on the comparative commercial advantages and disadvantages of live steam and exhaust steam turbines as applied to plants where large amounts of the latter are freely available. The article is of interest as it shows that although the initial cost of a live steam plant is about 40 per cent below that of mixed live and exhaust steam installations, the saving with the latter is, under the conditions specified, so great that the difference in the initial cost may be recovered in two or three years.

Under Thermodynamics is reported a discussion of what the author terms a thermodynamic paradox, a case where apparently more heat is recovered than is actually put in in coal at the generating end of the plant. As a matter of fact, Lord Kelvin, many years ago, predicted its possibility on theoretical grounds.

An investigation of fusible tin boiler plugs is reported from a paper published by the American Chemical Society. The outstanding points of the investigation are that unless the fusible plug is properly made, it may become a source of danger instead of being an element of safety. It was further found that pure Banca tin was not and is not being used in the filling of a considerable number of plugs on the market, but while no change would be detected in samples of pure tin under certain conditions of treatment, when lead was present, the filling, with same treatment would become porous at a comparatively low temperature, while in other cases tin oxide formed, having a higher temperature than the steel of the boiler plates themselves. From this investigation it appears, therefore, on the whole, that the purity of the metal used in the filling ought to be given much more attention than has been the practice hitherto.

A phenomenon known as a "hydraulic jump" is discussed in a paper before the American Society of Civil Engineers. The author discusses mathematically the relation between the depth, head and maximum discharge of controlling sections and indicates the nature of the hydraulic jump and the conditions under which it originates.

Several papers are reported from preliminary publications to the meeting at Atlantic City of September 28 to 30, 1915. Methods of reclamation of magnalium from turnings were discussed by John Caulson. S. Trood presented a paper on sherardizing, in which he investigates the process of sherardizing from the point of view of ionic relations between vapors of metals present in the sherardizing drum and shows the great influence of pressure in the drum, uniformity of zinc dust and heat and quality of iron. The paper is of considerable practical value and throws a good deal of light on this still somewhat incompletely understood process. The manufacture and use of alloy of vanadium and aluminum is discussed by W. W. Clark. It is shown that the alloy can be easily made, but that its field of application is rather limited. S. W. Parr gives the chemical composition of an acid resisting alloy. Its acid resisting properties appear to have been fully established, but methods of casting seem to still require further developments.

Two papers on asphaltic and bitulithic pavements are reported from the Journal of the Association of Engineering Societies. In connection with one of these papers is reproduced a table giving a summary of cost data for various kinds of pavements (collected in the State of Oregon).

In an abstract from a paper before the British Association are given some data on testing tool steels and in particular on a dynamometer used for such tests.

James J. Guest, in a paper abstracted in the Journal of the Institute of Mechanical Engineers, gives an interesting presentation of the theory of grinding, with reference to the selection of speeds in plain and internal work. From the same source has been made an abstract of a paper by H. Mowson on struts and tie rods in motion, of interest because it shows that formulae which have been derived for forces in stationary struts are only special cases of those obtained for rods in motion. Among other things, the author discusses in detail the case of a particular locomotive coupling rod which broke while in service and shows that the stress in the rod increases very rapidly as the speed of the engine increases, and that at very high speeds an increase of steam pressure does not appear to have as disastrous an effect as an increase of speed.

In a paper on safety valves before the Scientific Society of the Royal Technical College, Glasgow, D. MacNichol reports on the work which was done by the British builders on the design of safety valves for oil fuel vessels. It is of interest to point out in this connection that (The Journal, August 1915, p. 481), the German manufacturers, who like-

wise use a formula (the Caro equation) derived from coal burning boilers, found that their formula did not take care of the generation of steam in oil burning plants.

Those who are interested in the utilization of solar energy are referred to the brief abstract of a paper on this subject by A. S. E. Ackerman before the Society of Engineers (London).

FOREIGN REVIEW

Firing

Powdered Coal Preparation and Firing in Germany.

In modern German plants for the preparation of powdered coal for firing in furnaces, the following is the accepted fundamental principle: simplicity of machinery and apparatus used, and accessibility of the whole arrangement. The operation, which must be entirely automatic, must be carried out by as small an amount of reliable machinery as possible, so that it can be operated without trouble by unskilled labor. The

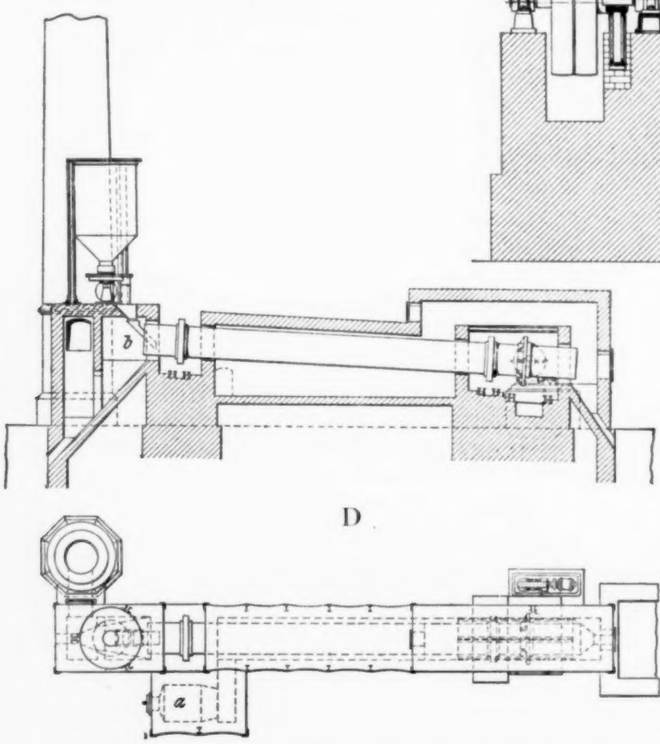


Fig. 1 *A*, Cementor Coal Crushing Mill; *D*, Polysius Drying Drum

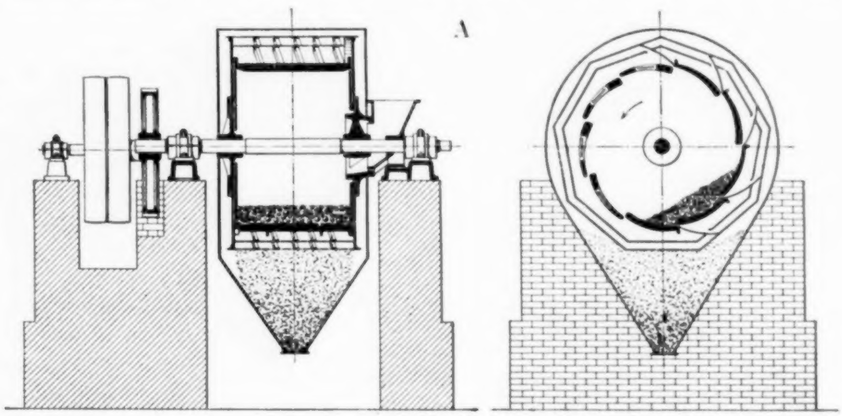
path of the material should be as short as possible and as close as possible to a straight line.

In German plants particular attention is directed to simplicity of construction of the grinder, in which respect the German construction differs materially from American, and even though some typical American crushers,—e.g., the Fuller-Lehigh,—have been adopted in some German plants, as a rule they have not found ready application in that country, and for the same reason, the high speed machinery of this type built in Germany itself has not been much used.

Where the plants using powdered coal have efficient repair shops and skilled mechanics available, oscillating crushers and similar apparatus can be used without much difficulty and with certain advantages; otherwise, however, the saving effected by their use will be more than eaten up by interruptions in the operation of the plant.

In the modern German plant nearly everywhere one finds slow running grinders with a large area of crushing, mainly of the ball and tube mill type. The larger amount of power consumption as compared with high speed machinery does not particularly matter here. Ball and tube mills are as a rule located one over the other, so that the grist produced by the ball mill can go directly to the tube mill and be converted into fine powder.

In order to improve the screening action, several types of ball mills have been placed on the market; for example, the so-called Cementor mill of Polysius, Dessau, Germany. Contrary to the usual practice in ball mills, this construction has unperforated crushing plates, these plates being located be-

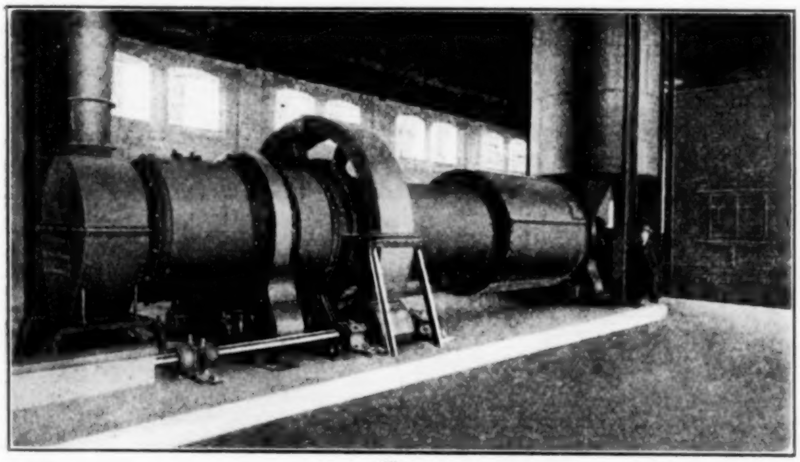


tween the walls in such a manner as to form stages with each other. With this construction, the grist is forced to run through the entire path of the grinding, passes over the sieve and is then partly returned in a uniform manner into the grinding drum. Fig. 1A indicates diagrammatically the fundamental principle of this design, while Fig. B shows the combination of a Cementor mill and a tube mill.

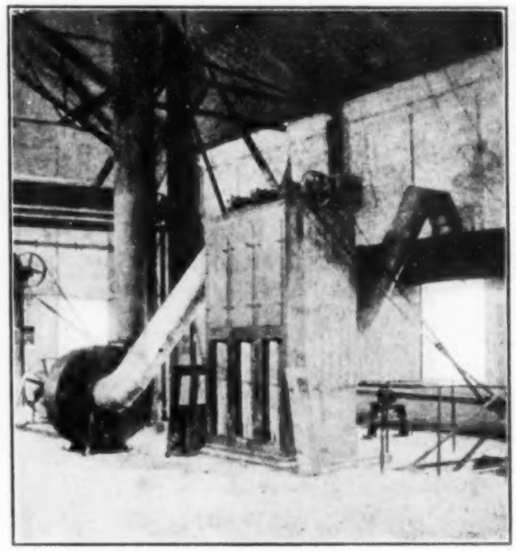
The high cost of foundations which such an arrangement involves, and the effort to simplify still more the grinding, led to the design of a machine which could carry out the crushing and fine grinding in one continuous series of operation. This resulted in the design of a combined crusher and grinder, forming one cylinder, a design particularly adapted for use in steel mills because of its extraordinary simplicity. This type of machine, called "Solo" mill, is likewise built in Germany by G. Polysius, Dessau (Fig. C), and consists of a seamlessly welded sheet cylinder running in circular bearings. This cylinder is divided by a wall into two chambers, one the crushing chamber with hard steel plates and steel balls, and the other the fine grinding chamber with Silex lining and quartz stones. The crushing chamber is surrounded with screens, and is enclosed in a sheet steel jacket, and can crush pieces as large as a man's fist. This grist then falls through slots at the end of the crushing chamber upon screens over which it travels, just as in the Cementor, to the admission side of the grinding mill. What remains over the screen is carried back into the crushing chamber while that which passes through the screen is delivered to the grinding chamber and handled there.

As compared with the oscillating and Fuller mills, this design has the advantage of handling pieces to the size of

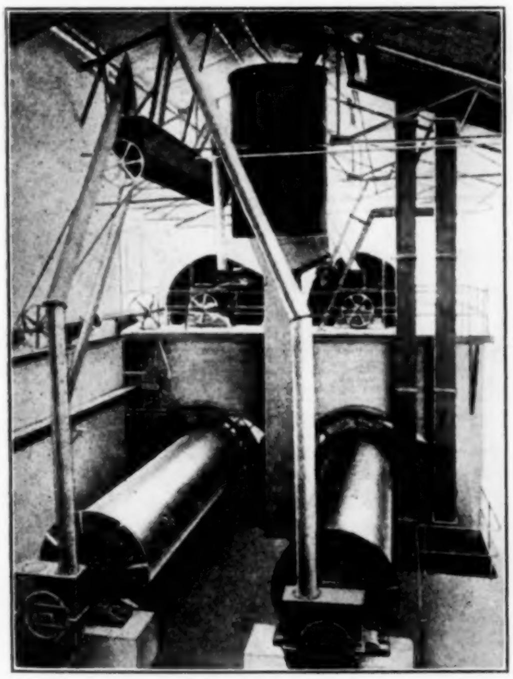
a man's fist; as compared with mills which require special separators, as in the Raymond crusher, there is the advantage that the Solo mill uses no cyclones, etc. In addition to that, there is the very important consideration that this type of mill insures to a very large extent against the occurrence of fires and explosions where the material handled has to be transferred from one apparatus to another, it is very difficult to provide against its escape and the formation of inflammable or explosive mixtures with air. In this case, as shown in Fig. D. The hot gases from the grate *a* play around the drum and pass through the interior of it and dust chamber *b*, into the smoke stack or the exhaustor, as the case may be. The gases when they reach the interior of the drum have so low a temperature that no gasification of the coal can take place. With very fine coal, special arrangements are provided to prevent the dust being carried away with the gases. The dimensions of the dust chamber are selected in accoradnce with the kind of coal to be dried.



C



G



B

E

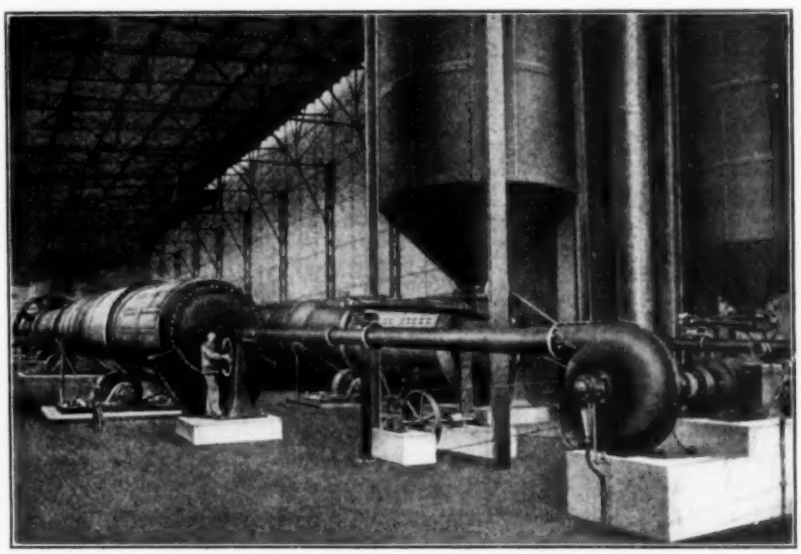


Fig. 1 *B*, Combination of Cementor Mill and Tube Mill; *C*, Solo Mill; *E*, Coal Heating; *G*, Suction Dust Filter

this source of danger is eliminated to a large extent, and the author states that explosions have never occurred in mills of the Polysius type. The objection is often made to crushers operated with screens on account of their rapid wear; in the Solo mill these screens consist of perforated steel sheets of high resistance, in addition to which the construction is such that large pieces of iron that cause most of the wear cannot reach the screen.

As a rule, the Polysius Company build their drying drums The brickwork is sometimes laid funnel-shaped at the bottom, so as to allow the dust settling on the walls, to fall into the container below. The drum may also be very conveniently heated by blast furnace or coke oven gases. The system of heating proper, as shown in Fig. E, is derived from that used in America.

Double worms are provided for carrying the coal dust from the storage bins, the windings of the two worm spirals being staggered with respect to one another, which ensures

a uniform supply of coal dust. The speed of rotation of the conveyor is adjustable by means of the Polysius governor (not shown in detail), which can be made to act simultaneously on the throttle in the air supply so as to vary the amount of blast in proportion to the increase and decrease of the coal dust handled. A special indicator is also provided, permitting the reading of the amount of coal dust used. The suction piping of the high pressure fan is connected with the cooling drum or such device as is used for conveying the sintered or roasted material; it delivers air of combustion preheated to from 300 to 400 deg. cent. (572 to 752 deg. fahr.). One part of this air is taken in by suction through the exhaustor, while the rest goes through the smoke stack. In rotary cement kilns, an excess of air is usually admitted and the amount of air is governed by a throttle located at the smoke stack.

by means of a suction fan. Similar filters have been recently introduced in iron plants to clean blast furnace gases. The author points out that the use of such devices for cleaning air and the protection of workmen considerably increase the cost of installation of German plants as compared with American plants, which fact, however, ought not to be weighed against the safety of the workmen and their improved state of health. (*Neuerungen in Kohlenstaubfeuerungen, Stahl und Eisen*, vol. 35, no. 38, p. 965, September 23, 1915, 6 pp., 9 figs. *d.*)

Internal Combustion Engines

Processes of Combustion in a Hot Bulb Engine, Erich Weisshaar.

Experimental and theoretical investigation of the processes of combustion in a hot bulb engine.

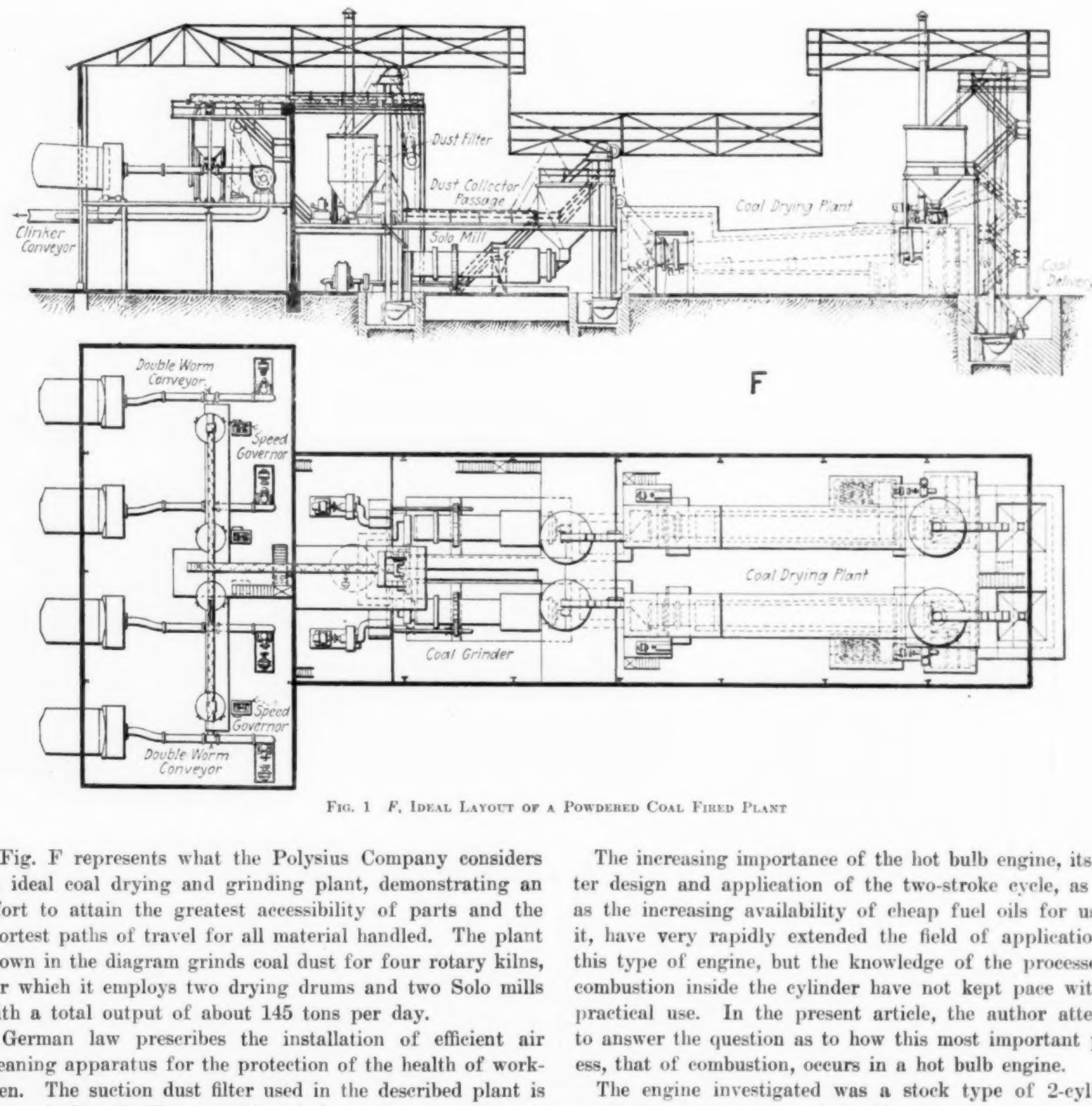


Fig. 1 *F*, Ideal Layout of a Powdered Coal Fired Plant

Fig. F represents what the Polysius Company considers an ideal coal drying and grinding plant, demonstrating an effort to attain the greatest accessibility of parts and the shortest paths of travel for all material handled. The plant shown in the diagram grinds coal dust for four rotary kilns, for which it employs two drying drums and two Solo mills with a total output of about 145 tons per day.

German law prescribes the installation of efficient air cleaning apparatus for the protection of the health of workmen. The suction dust filter used in the described plant is shown in Fig. G. The air, with such dust as it may contain, is taken from all the machines of the coal grinding mill, and driven through a center passage and then through the filter

The increasing importance of the hot bulb engine, its better design and application of the two-stroke cycle, as well as the increasing availability of cheap fuel oils for use in it, have very rapidly extended the field of application of this type of engine, but the knowledge of the processes of combustion inside the cylinder have not kept pace with its practical use. In the present article, the author attempts to answer the question as to how this most important process, that of combustion, occurs in a hot bulb engine.

The engine investigated was a stock type of 2-cylinder crude oil marine engine of the Maschinenbau A.-G. vormals Ph. Swiderski, adapted for land use by reduction of the speed of rotation. It was loaded very uniformly by a drive

to a centrifugal pump, and was fed with tar oil and some gas oil. Only very little water had to be injected. The amount of tar oil and water was regulated by a governor, while the addition of gas oil remained constant. The engine had the following dimensions:

Cylinder 1
- Diameter....................322 mm (12.67 in.)
- Stroke......................381 mm (14.99 in.)

Cylinder 2
- Diameter....................320 mm (12.59 in.)
- Stroke......................379 mm (14.91 in.)

The opening of the exhaust port begins at 0.72 of the piston stroke: average speed of rotation, 261 r.p.m.

The diagrams show quite material oscillations in the expansion line which were equalized by placing above and below the oscillation, enveloping curves and plotting an average curve between these two. Such a method is permissible because it may be assumed that we have to deal here with damp free oscillations. Four diagram sets of ten 2-strokes each, were carefully measured for each cylinder and all

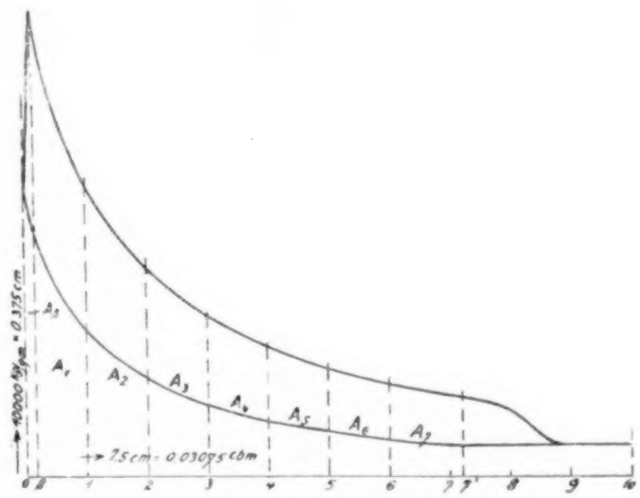


FIG. 2 AVERAGE DIAGRAM OF PROCESSES IN A HOT BULB ENGINE

combined, on an enlarged scale, into a single average diagram, Fig. 2. The maximum pressure could not be determined with certainty from the enveloping curves, and it was plotted in such a manner that the corresponding point on the heat diagram would not have an impossible location. The average diagram shows an average pressure of 2.27 kg. per ccm. (32.28 lb. per sq. in.), so that the indicated output amounts to 81 h.p. Since the efficiency of the pump and its ability were known only approximately, the effective output could only be estimated, and was taken to be 60 h.p.

The author discusses in detail the process of combustion, in the following manner:

When the piston is at the upper dead center, there is contained in the compressed mixture of exhaust gases and air a quantity of heat J_o. To this has to be added the quantity of heat, Q, contained in the oil and becoming free on combustion. At the point 7′, when the exhaust port is open, there is contained in the gas a quantity of heat J_7. On the way from the dead point to the opening of the slot, there is delivered a quantity of work, A, represented by the area between the ordinates O and 7^1 on one hand and the expansion

TABLE I NUMERICAL DATA TO FIG. 1

Ordinates	Stress in kg./qm. (1 kg./qm. = 0.00142 lb. per sq. in.)	Volumes in cbm. 1 cbm. = 35.314 cub. ft.)	Gas constant	Absolute temperature (deg. cent.)	Heat transmission in WE/qm.hr. (1 WE/qm.hr. = 0.37 B.t.u. per sq. ft. per hr.)	Area in qm. (1 qm. = 10.7 sq. ft.)	WE per hr. (1 WE = 3.968 B.t.u.
	p	V	R	T	W	F	$F\ W$
0	95,500	0.00633	29.20	918	51,000	0.1965	10,020
β	154,000	0.00664	29.00	1,518	271,000	0.2003	54,300
1	96,000	0.00942	29.00	1,341	177,000	0.2349	41,600
2	69,200	0.01248	29.00	1,281	151,000	0.2733	41,300
3	53,050	0.01556	28.90	1,230	131,500	0.3117	41,100
4	42,850	0.01863	28.90	1,189	118,000	0.3502	41,300
5	35,700	0.02171	28.80	1,160	108,000	0.3885	42,000
6	30,600	0.02478	28.80	1,133	100,000	0.4270	42,700
7	26,200	0.02850	28.80	1,116	95,000	0.4733	45,000

and zero lines on the other hand (This work is expressed here in calories).

On the other hand, because of cooling during the same period of the motion of the piston, there is a loss through cooling of quantity of heat q_w, to which has to be added the heat loss q_r, due to the fact that a part of the oil is taken out by the exhaust, incompletely burned, in the form of carbon monoxide and incandescent soot. Since there must be an equilibrium between the quantities of heat added and taken out:

$$J_o + Q = J_7 + A + Q_w + Q_r$$

in this equation J_o and J_7 can be determined from the gas temperatures T_o and T_7, provided the weight of gas G in the cylinder is known (The specific weight of gas is here assumed to be variable).

For the determination of heat losses, q_w, due to cooling, the author uses an expression which he previously derived for the case of a Diesel engine. The determination of the weight of gas present in the cylinder during the comparison and expansion is a rather difficult experimental proposition (*Der Verlauf der Verbrennung im Glühaubenmotor,* Erich Weisshaar, *Der Oelmotor,* vol. 6, no. 5, p. 151, August 1915, 6 pp., 4 figs., *et*).

Steam Engineering

1250 KW MIXED PRESSURE TURBO-GENERATOR, F. Schulte

Description of a mixed pressure turbo-generator and calculations showing the commercial advantages and disadvantages of live steam and exhaust steam turbines under certain predetermined conditions.

In this instance, there was an electric generating plant at one of the two mines of the same company, but with the growth of business, its output ceased to be sufficient. There was available at the plant approximately 11,000 kg. (24,200 lb.) of exhaust steam per hour, and at a consumption of 16 kg. (35.2 lb.) per kw-hr., approximately 700 kw. could be obtained from this source. About 1000 kw. were considered necessary; hence, about 300 kw. would have to be generated by live steam if a mixed pressure turbine were used. It is clear that the selection of type of turbine was to be determined principally by economic considerations.

An investigation showed that the first cost of pure live steam turbines, with equipment and buildings, would be

155,000 marks (roughly $38,000) in addition to which another boiler plant, costing 49,500 marks would have to be installed, thus bringing up the first cost to about 204,500 marks.

A mixed pressure turbine, with all its equipment and buildings, would cost 255,000 marks, or about 50,000 marks more than a live steam turbine and the additional boiler plant. On the other hand, the operating costs, under the assumption that the turbine would run 16 hours per day, under full load, and that during this time there would be available 700 kw. exhaust steam, would be as follows:

A—Live Steam Turbine	Marks
1. Interest and depreciation on first cost at the rate of 10 per cent	20,470
2. Attendance, 16 hr. per day and 300 working days per year	1,920
3. Cost of live steam, 16 hr. per day, 300 days per year, with steam consumption of 9 kg. (19.8 lb.) per kw-hr. (under the assumption that 1000 kg. would cost 160 marks)	69,120
4. Lubricating oil	490
5. Repairs	1,400
6. Cost of attendance on the three additional boilers	2,800
Total operating cost	96,200

B—Exhaust Steam Turbine	Marks
1. Interest and depreciation of plant at the rate of 10 per cent	25,500
2. Attendance, 16 hr. per day, 300 working days per year	1,920
3. Cost of live steam for 300 kw., 16 hr. per day, 300 days per year (under the assumption of 9.5 kg. per kw-hr.)	21,880
4. Lubricating oil	500
5. Repairs	1,000
Total operating cost	50,800

Which shows that the operating cost of a live steam turbine is approximately 45,400 marks per year higher than the cost of the exhaust steam turbine. Actually, however, the saving in operating expenses with the exhaust steam turbine will be considerably lower, partly because some of the exhaust steam would be utilized for the preheating of feed water and partly because the exhaust steam from the hoisting engines is available at irregular intervals and may thus to a certain extent have to be exhausted into the atmosphere.

The paper describes in detail the construction of the turbine condensing plant and steam accumulator and gives as well data of tests with pure live steam and pure exhaust steam as driving media. Tests have shown that the steam consumption either way was below the guaranteed amount and that the expectations from the economic point of view were satisfactorily fulfilled. A striking indication of the saving through utilization of the exhaust steam is given in the fact that before the installation of the turbine, about 3000 to 4000 marks ($750 to $1000) worth of current was purchased from outside sources, while after the turbine has been installed, not only has this entire amount been saved, but an opportunity for a source of profit of about 3000 marks ($750) from the sale of current was opened, while the steam consumption of the mine remained at the former level. (*Mischdruck-Turbogenerator für 1250 kw. der Zeche Neu-Iserlohn I der Harpener Bergbau-Akt. Ges.*, F. Schulte, *Zeits. des Vereines deutscher Ingenieure*, vol. 59, no. 39, p. 785, September 25, 1915, 6 pp., 6 figs., *dp.*)

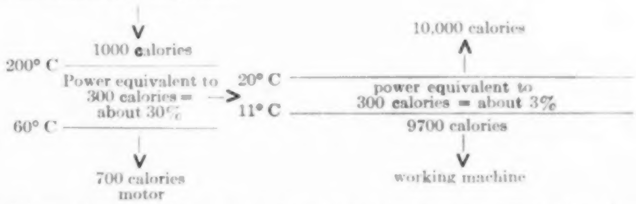
Thermodynamics

A Thermodynamic Paradox.

The paradox which the author considers, exists in the fact that under certain conditions, the total amount of heat developed in machinery from a pound of coal, appears to be larger than that initially contained in the coal. The possibility of this was first pointed out by Professor Thompson (Lord Kelvin) and since utilized in the refrigerating system of Altenkirch (see the Journal, October 1913, p. 1574).

The author questions whether a refrigerating machine can be used as a heat generator, apart from the consideration of its output of cold, and shows that if this be done, apparently an excess of heat is produced. The whole point lies in the fact that refrigerating machinery may produce not only cold in the evaporator, but also heat in the condenser. If the heat generation be considered the main purpose of such a machine, then, with a small temperature difference, an amount of heat could be made available in excess of that consumed in the motor driving it. The situation is as if the power transferred to the refrigerating machine had the properties of a ferment. The output of cold and heat is not equivalent to this power, the latter giving simply the impetus of an incomparably greater heat transformation.

In two mechanically connected cycle processes, a large temperature difference with a small amount of heat in the first process, creates a large output of heat with a small temperature difference in the second process, in accordance with the following diagram:



There is no doubt, of course, that the heat generated in the compressor is equivalent to the amount of power consumed. Hence this amount of heat is small, but when steam is liquefied at a higher temperature, a large amount of latent heat is freed (the amount which was tied up at the lower temperature in the evaporator) and it is this amount of heat which is of determining influence. As an example, the author gives the following particular case:

A good steam engine requires 0.75 kg. (1.6 lb.) of coal per effective h.p-hr. One h.p-hr. is equivalent to 637 calories. If one takes the heating value of coal to be 5600 calories (10,800 B.t.u. per lb.), then 4200 calories have been used up and the utilization of heat may be taken to be only 15 per cent. An ice making machine has been tested in this respect, and produced at 14.75 effective h.p. in the condenser, 7250 calories per hr., or 4915 calories per effective h.p-hr., so that with all losses, there has been actually obtained with an expenditure of 4200 calories, an output of 4900 calories (with a Diesel engine, 4900 calories can be obtained with an expenditure of only 2200 calories).

(Of course the above does not really conflict with the accepted laws of the mechanical theory of heat, as has been

previously shown by Lord Kelvin. Editor's note) (*Ein "Paradoxon" aus der mechanischen Wärmetheorie,* Johs. A. F. Engel, *Dinglers polytechnisches Journal,* vol. 330, no. 15, p. 289, July 24, 1915, 2 pp., *t.*)

Miscellanea

LAWS OF DETERIORATION OF TELEGRAPH POLES, Fr. Moll.

The paper discusses the laws of deterioration of wooden poles used for the suspension of electric wires, in particular, telegraph poles. The author points out that the entire matter of impregnation engineering is still in its initial stages of development, and the subject of the efficiency of impregnating materials has been investigated only to a limited extent.

The main question in this connection is, what is the relation between the chemical constituents of the impregnating materials and their efficiency as inhibitors of decay. The work of Netzsch has shown, for the group of salts of fluorine, that salts in the solution of which free ions of fluorine are developed, have an efficiency practically proportional to the contents of fluorine in the salt. The present writer has established a similar relation for a number of salts of zinc with regard to the contents of zinc metal, and it appears, therefore, that the inhibiting action is dependent either upon the presence of acid ions or metal ions. If, however, both are at work, the investigation becomes much more difficult and more extensive experimentation is required in order to establish the law of inhibitory action. It may here be mentioned that most of the so-called "data of tests" published as advertising matter by various manufacturers of impregnating materials can be considered as entirely worthless in this connection.

In the absence of sufficient reliable data on the efficiency of impregnating materials, the best source of information appears to be statistical data on the life of various types of telegraph poles. In Germany such data have been collected since 1850 and published at various periods, in particular, by Christiani in 1905. These data have shown that of all of the processes of impregnation those using kyanization and impregnation with tar oil, have given the best results. The economic value of impregnating poles may be determined in accordance with the following formula:

$$\text{Economic efficiency} = \text{average cost per annum} = \frac{\text{cost of operation}}{\text{average life.}}$$

The cost of operation includes of course both the impregnation and the delivery of the poles to the spot, and is, as a rule, given by the accepted bids, but the average life of the pole is, to a greater or less degree, an unknown quantity. Some data are given in the German publication, *Archiv für Post und Telegraphie,* 1913, p. 229, where the life of poles of various kinds of wood, with and without impregnation, is given as compiled from data published by telegraph administrations all over the world. From this publication the writer cites Table 2.

On the whole, the author comes to the conclusion that the life of impregnated poles may be predetermined by the application of the usual laws of probability and that the destruction of wooden poles through decay follows the usual probability curve. He gives for it the following equation:

$$y = \frac{0.564h}{e^{h^2 x^2}}$$

in which x and y are, as usual, unknown quantities, e is the basis of natural logarithms, h, a constant which may be denoted as a parameter and has a different value for each average period of life of the post; for any average life of post, h may be expressed in the following manner:

$$h = \frac{0.477 \times 5}{\text{average life}}$$

Thus, for the average life of 20 years, which is about what is obtained from kyanization, and poles impregnated in a

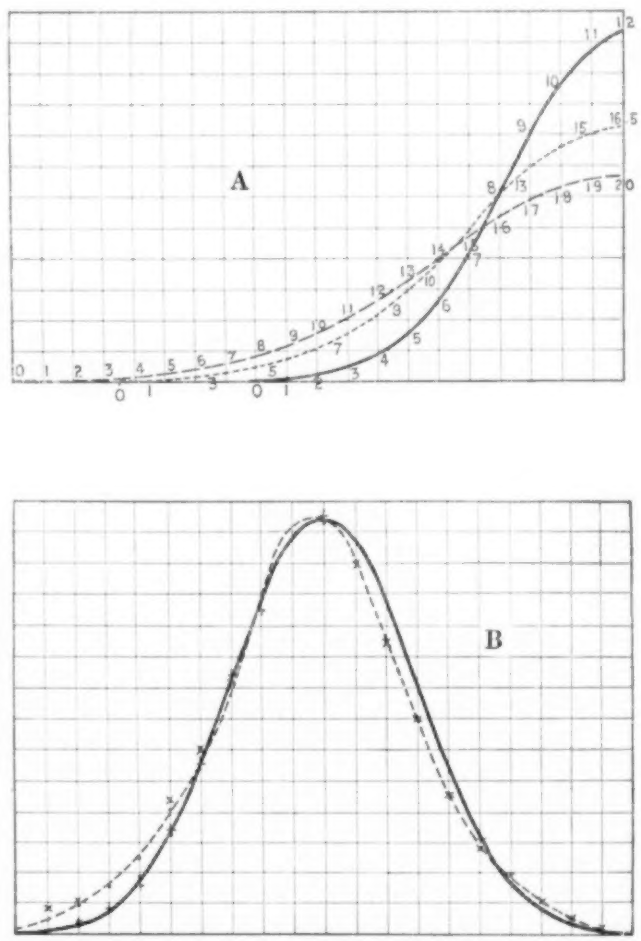


FIG. 3 ACTUAL AND PROBABILITY CURVES OF DECAY OF TELEGRAPH POLES

proper manner with tar oil, the curve of probable exchange of poles has the following shape:

$$y = \frac{0.564 \times 0.096}{e^{0.096^2 \times x^2}} = \frac{0.0541}{e^{0.00012 \times x^2}}$$

The author gives the following two curves: curve 3*A* indicating the average line of necessary exchange derived from 40 statistical compilations. This curve was recomputed on the basis of an average life of ten years. One division on the abscissa line corresponds to one year in the statistical data and the total length of the abscissae is 20 years; the

ordinates indicate the approximate amounts of exchange of poles in the years given by the abscissae, one division of the ordinates giving one per cent of the total number of poles. For purposes of comparison there is drawn in full lines over the curve of actual exchanges, the curve of probability.

Fig. B gives the curve of probability for a value of h, corresponding to an average life of twelve years, 16.5 years and 20 years. Only the left part of the symmetrical curve is drawn. In the abscissae, one division corresponds to one year of life in the ordinates, which division corresponds to 1 per cent of the total number of poles. The ordinates give, therefore, the accepted approximate yearly exchange of poles. (*Die Gesetzmässigkeiten im Abfall hölzerner Maste für elektrische Leitungen,* Dr.-Ing. Friedrich Moll, *Elektrotechnische Zeitschrift,* vol. 36, no. 35, p. 449, September 2, 1915, 2 pp., 2 figs. *st*).

ENGINEERING SOCIETIES

AMERICAN CHEMICAL SOCIETY

Journal of Industrial and Engineering Chemistry, vol. 7, no. 10, October 1915, New York City.

An Investigation of Fusible Tin Boiler Plugs, G. K. Burgess and P. D. Merica.

The investigation was prompted by the explosion on May 11, 1914, of a boiler on the steamship *Jefferson,* which subsequent investigation showed to have been due to low water and consequent overheating of the boiler plates. This should have been indicated by the fusion of the filling of the tin fusible plug in that region, but the plug was found to be unmelted and superficially sound. When the plug was sent to the Bureau of Standards for investigation and there was sawed open longitudinally, it was found to contain only traces of the original tin imbedded in a dirty greenish matrix consisting largely of tin oxide. This oxide has a melting point of about 2900 deg. fahr., and it was distributed in such a form and quantity that it held the pressure of the boiler. As a matter of fact, instead of being an easily fusible material, it would not have melted until the bronze of the casing and even the steel of the boiler had melted, and instead of being a factor of safety, it was a menace.

TABLE 2 AVERAGE LIFE OF TELEGRAPH POLES OF VARIOUS WOODS

Untreated	*Years*
Oak (Hungarian)	7
Cypress	8 to 10
Larch (Austrian)	10
Chestnut	10
Cedar (N. America)	15

As no data as to the worth of fusible tin plugs of this sort were found in technical literature, the steamboat inspectors were requested to send in to the Bureau more plugs for testing purposes and in answer to the request, about 250 plugs were received, of which about 100 had been in service varying from four to twelve months. These plugs represented the products of some 105 firms.

The plugs were classified according to the degrees of deterioration. Some were found to be partially melted away; others with fillings expanded in service, corroded or pressed in at the water side. In some plugs, non-metallic formations or incrustations were found in the filling, such as zinc oxide or copper oxide. It appears practically certain that this oxidation occurred in service and that the oxide was not poured in with the tin generally. In order to determine the relation between the temperature values found and the purity of the tin in the fillings, the melting points of a number of the old plugs, as well as new ones, were taken and chemical analyses made of the fillings showing abnormal melting points. It was found that Banca tin was not and is not being used in the filling of a considerable number of plugs. Of 35 plugs analyzed chemically, only six fillings showed 0.20 per cent or less impurities, or only six out of the 35 were composed of any variety of high grade tin. The principal impurities were lead or zinc. Of about 70 melting point determinations made on used and new plugs, only eleven gave values within 0.5 deg. cent. of the melting point of pure Banca or Straights tin.

Plugs with fillings that had a low melting point and contained zinc, showed what the author calls "network" type of oxidation, which he explains by the constitution of the zinc-tin alloy and its behavior on cooling. In the zinc-tin alloy of certain particular types, the tin crystals are surrounded by an envelope of zinc. If this alloy be brought in contact with a corrosive aqueous solution, the latter will attack the zinc first, eating its way into the plug through the grain or crystal interstices, and the tin filling finally becomes honeycombed in structure. The corrosion of the tin itself may start from these crystalline canals and the oxidation produced remain, forming gradually the oxide network structure already referred to. Alkaline waters, such as would be produced by over addition of soda boiler-water softener, attack zinc even at ordinary temperatures and probably corrode tin at high temperatures. The temperature of the water and plug will determine to a greater extent the rapidity of the progress made by the oxidation.

A number of new plugs, as well as plugs made up at the Bureau, containing definite amounts of impurities, were subjected to the action of water at high temperatures to determine what would be their behavior under these known conditions. For this purpose, the plugs were put in a copper autoclave and heated for various periods at a temperature of from 180 to 195 deg. cent. in either tap or distilled water. Of 14 new plugs, heated for 195 hours and 20 new plugs for 140 hours in tap water, only three showed any change whatever. These were all from one manufacturer and contained lead in varying amounts. All were somewhat distorted and covered with spongy abrasions. Whereas no lead could be detected in the microstructure before heating, after heating the lead had coalesced as an enveloping boundary to the tin crystals.

The plugs containing zinc and lead in amounts equal to or above 0.5 per cent were generally found cracked after heating for about 500 hours at from 350 to 380 deg. fahr. In some cases, particularly when lead was present, the filling had become porous due to the melting out of the low melting eutectoid, which in this case melts around 170 deg. cent. (330 deg. fahr.). *No change could be detected in the samples of Banca or Straights tin caused by this treatment, other than a slight surface oxidation.*

The article discusses briefly the testing of the purity of zinc. The most important conclusion to which the author comes is that the use of *pure* tin would probably eliminate danger of oxidation of plugs in service (6 pp., 7 figs., *ep. A*).

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 41, no. 7, September 1915, New York City

THE HYDRAULIC JUMP, IN OPEN-CHANNEL FLOW AT HIGH VELOCITY, Karl R. Kennison

When water is discharged into a flume through a contracted gateway and under a considerable head it sometimes continues to move in a thin sheet at a high velocity along the bottom of the flume for several hundred feet. Then it suddenly becomes turbulent and forms what is called a "hydraulic jump," the surface level down stream from this point being very much higher than that of the approaching high velocity discharge. Another case is when water flows over an ogee dam and out on a smooth apron; then it sometimes continues in a thin sheet having a surface level far below the normal level of the river until it suddenly changes into a tumbling mass rising to the normal river level by this hydraulic jump. This phenomenon is sometimes of great practical importance in connection with the design of dams; for example, in one case it was desirable that the back roll or hydraulic jump should not be allowed to extend far off down stream below the foot of the ogee, from a concrete apron which protected the clay river bed from scour. In another case, it was desirable that the hydraulic jump should not extend down stream so far as to interfere by its violent surges with the draft tube exits of a power house.

The author discusses mathematically the relation between depth, head and discharge and the maximum discharge of controlling sections. He comes to the following general conclusions:

In the case of water flowing in an open channel on a steep gradient there are certain controlling sections which throttle the flow and determine the quantity of the discharge. If the contraction which causes this throttling of the flow is sufficiently gradual, for example, a submerged dam with smooth gradual approach and getaway, it can be shown that the depth of water at this point is theoretically two-thirds of the total head measured from the channel bottom or dam crest up to the hydraulic gradient, and the discharge per foot of length should be $3.09\ H\ 3 \div 2$.

At other points than at the controlling section, the depth of water is not necessarily determined by the quantity discharged and the available head, but also by the channel conditions. The upper stage is the normal level in an ordinary stream and for very low velocities is practically coincident with the hydraulic gradient. The lower stage is that ordinarily taken by water discharged at high velocity from an orifice or below a spillway dam. In other words, it can be shown that in any open channel, except at controlling sections, there is in addition to the existing water level another level at which the same quantity of water might be flowing with equal steadiness and under the same head or elevation of hydraulic gradient.

In the case of smooth, undisturbed flow the stream must stand at one of these two levels; that is, water flowing in a smooth channel of a uniform section must continue to flow at its existing stage, whichever one that happens to be, until for some reason it encounters a controlling section where the two alternative stages merge into one and the depth is two-thirds of the total head. Below this controlling section, the two possible stages again separate. At such a point as this, the water level may change without disturbance or interruption of the steady flow from one stage to another, or may continue in the same stage. Thus the water behind the spillway dam is approaching at the upper stage and just below the dam it flows away at the lower stage. The change occurs smoothly over the dam where the two stages are merged into one, but if the dam is submerged by back water almost as high as the up-stream pool, the surface may simply dip down locally at the dam where the depth is two-thirds of the head. In such a case the upper alternative stage is maintained throughout, below as well as above the dam. Usually the presence of the controlling section tends to conceal the existence of the two alternative stages, but water flowing at the lower high velocity stage and suddenly encountering obstructions which tend to destroy its velocity, may rise suddenly, and with considerable disturbance and eddying, to the more stable upper low velocity stage, thus forming what is known as the hydraulic jump.

The only energy lost in this phenomenon is that used by accompanying disturbance and eddying, as the jump proper merely converts kinetic into potential energy. Ordinarily, however, when appearing below a spillway dam, the hydraulic jump is accompanied by such violent disturbance and eddying that the total surplus energy in the water may be destroyed in this way (15 pp., 13 figs., *mA*).

AMERICAN INSTITUTE OF METALS

Preliminary publication of papers read at the meeting at Atlantic City, September 28 to 30, 1915

RECLAMATION OF MAGNALIUM FROM TURNINGS, John Coulson

The use of magnalium metal (an alloy of aluminum and magnesium) for finished castings has increased to such an extent that the recovery of the metal from the turnings has become an important factor. The difficulty of the operation consists in the fact that the oxidation of finely divided magnalium is extremely rapid, and, unless some process of agitating the melted material is applied, the oxide film will prevent it from fusing together.

Fluxes composed of chlorides and fluorides of the alkaline earths have been used with some success, as well as cryolite. The latter, however, is objectionable, since it attacks silicon and graphite crucibles. To avoid the difficulties involved in the use of the various fluxes, a method has been developed of using inert gases; hydrogen has been found to give the best result. As a fluxing agent common salt was used. The turnings were boiled for a few minutes in a 4 per cent salt

solution, which was then poured off and took with it the objectionable scum. The gas pressure was applied through a pipe overhead. It was even found that the turnings could be melted in an open crucible after they had been boiled in a solution of slightly fluxing salt. The damp turnings were turned into a crucible heated to 900 deg. Cent., and by mechanical means were forced to coalesce as they melted, each addition of turnings being thoroughly puddled until the mass became uniformly viscous. After the last puddling operation, the charge was left standing in the hot crucible for ten or fifteen minutes which gave the oxide time to rise to the surface, where it was held while the clean metal was poured from underneath.

The metal recovered from the turnings contains some oxide and is therefore not as good as the original magnalium, but its physical characteristics can be improved by the introduction of a deoxidizing agent, e.g., 1 per cent of metallic calcium or ½ per cent of calcium aluminum silicide (7 pp., *d*).

Sherardizing, S. Trood

The paper presents an investigation of the process of sherardizing, an explanation of the usual lack of uniformity of results and directions for making the results uniform and for reducing the time required for the process. A brief history of the process is given in the introductory paragraphs.

The author shows that in the sherardizing drum there are microscopically small globules of zinc vapor surrounding the particles of zinc oxide and charged electrically. In addition to that, there are gases emanating from iron and also carrying ionic charges. Iron and zinc have different potentials. As a result, discharges must occur which, in their turn, precipitate solids from gases—that is, zinc and iron.

If that is so, the atmospheric pressure will have a considerable effect on the process as the vapor tension of the gas will vary with the pressure and the gases will be more readily given off in vacuum. To prove this, the author created a vacuum in a small sherardizing drum, and results were produced in ten minutes in a vacuum which would require six hours at the same temperature under atmospheric pressure. Since electric potential is higher for pure gases than for mixtures of gases, it is of advantage to have the zinc dust and iron in as pure a state as possible. The author comes to the conclusion, therefore, that uniformity of zinc dust, uniformity of heat, and the quality of iron are of great importance as affecting the uniformity of results. In addition to this, the proper time of sherardizing is an essential factor.

The best method of preparing the surface to be sherardized is shot air blasting. Sand blasting is not good because particles of sand penetrate the pores of the iron. Pickling requires great skill, and must be done very carefully, as often sulphates and phosphates are created on the surface and are hard to remove, in addition to which traces of salts, alkalies and acids after pickling may produce a retarding result when heated, so far as the ionic charges are concerned.

In the zinc dust, zinc should not be below 85 per cent, zinc oxide not below 8 per cent, and lead should be kept down to about 1.25 per cent.

Experiments have shown that when the percentage of lead is too high, lumpy deposits will appear on the plain sherardized surface. The zinc dust particles must be kept uniform in size. After deposit of the zinc begins, the thickness of the deposit depends solely upon the time. The coating which is being deposited when the temperature is going up is the most dense and durable. Next in quality will be the coating at uniform temperature, and the poorest when the temperature is going down (11 pp., *ep*).

The Manufacture and Use of Alumino-Vanadium, W. W. Clark

The paper discusses the manufacture and use of an aluminum-vanadium alloy intended for use as a carrier of vanadium in the non-ferrous alloys.

The alloy is manufactured in the following manner: Ingot aluminum is melted in a graphite crucible provided with top and bottom holes. The thermit mixture of vanadic oxide and granulated aluminum is then ignited on top of the molten metal. After it has all been reduced, the mass is stirred and the metal tapped. Aluminum-vanadium alloy can also be manufactured without difficulty in the electric furnace. The alloys are not pure as they contain a fraction of one per cent of iron in addition to small amounts of silicon and carbon.

There are several difficulties encountered in the use of aluminum-vanadium alloys. Aluminum in an alloy of copper and zinc, or copper, zinc and nickel, tends to make the metal brittle when rolled. If a metal is not perfectly deoxidized, aluminum oxide may be found enclosed. In drawing metal such as cupro-nickel, aluminum is objectionable, as the metal hardens too quickly. The author believes therefore that nickel and manganese alloys of vanadium may be more suitable. He also considers it very doubtful that small amounts of vanadium will increase the tensile strength of non-ferrous metals beyond that due to its powerful deoxidizing properties, and vanadium should not be used as a scavenger, as there are a number of as good and cheaper ones available. If, however, used with metal previously cleansed, vanadium in small amounts does increase the elongation (8 pp., *p*).

The Development of an Acid-Resisting Alloy, S. W. Parr

The paper discusses the development of an alloy which, in addition to being able to withstand the corrosive action of acids and gases, would be suitable for use where density, strength and working properties are essential, besides being considerably cheaper than platinum and available in larger amounts.

This latter condition necessitated the production of this material from base metals. After a considerable amount of experimentation, an alloy has been developed such that six discs made of it have shown no weighable loss after contact with 25 per cent nitric acid for twenty-four hours. The chemical composition of this alloy is rather complicated:

Cu	6.42
Mn	0.98
Si	1.04
W	2.13
Ni	60.65
Al	1.09
Fe	0.76
Cr	21.07
Mo	4.67
Total	98.81

It has been found, however, that each additional element lowers the melting point of the alloy, and reduces the tendency to form an open texture or coarsely crystallized structure.

The melting point of the alloy is approximately 1300 deg. cent. When thoroughly liquid, the alloy pours readily and fills the mold perfectly, but the freezing point is so quickly reached that feeding of the casting from risers to make up for shrinkage is practically impossible, while the shrinkage is so excessive that cracks and hollow spots are very difficult to avoid. The material works in a lathe about the same as tool steel. So far, the attempts to draw the alloy into wire and roll it into sheets have been only partially successful. The tensile strength of the cast metal is approximately 50,000 lb. per sq. in. (7 pp., 2 figs., *de*).

ASSOCIATION OF ENGINEERING SOCIETIES

Journal, vol. 55, no. 2/406, September 1915, St. Louis, Mo.

Asphaltic and Bitulithic Pavements:
 Cost of Raw Materials and Cost of Mixing, R. S. Dulin
 Cost of Grading, Hauling, Spreading, Rolling, etc., R. G. McMullen (both abstracted)

Asphaltic and Bitulithic Pavements: Cost of Raw Materials and Cost of Mixing, R. S. Dulin.

The paper presents cost data covering the items of raw material and mixing of asphaltic and bitulithic pavements, taken from data collected by the engineers of the city of Portland, Oregon. The unit prices used for the various ingredients in the pavement mixtures have been taken as the same for the same materials, no matter in which pavement they were used.

For various types of pavements, the author indicates the limiting proportions of the various ingredients and materials required by the specifications, as well as the mean of the various proportions actually used in the samples tested, and explains how the samples were taken. Table 3 gives a summary of the cost data for various pavements. This Table has been so arranged that pavements which are naturally competitive are placed consecutively. The comparative cost of the materials, for wearing surface, binder, base and entire pavement, are given for twelve different types of pavements (9 pp., *p*).

TABLE 3 SUMMARY COST OF DATA FOR PAVEMENTS.

Table of Cost of Materials per Square Yard of Finished Pavement.

Types of Pavements	Specifications No.	Wearing surface 2 in. thick	Wearing surface 1½ in. thick	Binder 1 in. thick	Bituminous base 3 in. thick	Crushed rock base 4 in. thick	Crushed rock base 1½ in. thick	Concrete base 5 in. thick	Total cost of material per square yard of finished pavement
Asphaltic Concrete on Bituminous Base	123	$0.195	.....	.....	$0.189	.....	.....	.....	$0.384
Gravel Bitulithic on Bituminous Base	132	0.171	.....	.....	0.189	.....	.....	.....	0.360
Asphaltic Concrete on Crushed Rock Base	122	.....	$0.146	$0.064	.....	$0.180	.....	.....	0.390
Bitulithic on Crushed Rock Base	131	0.171	.....	.....	.....	0.180	.....	.....	0.351
Asphaltic Concrete on Concrete Base	121	.....	0.146	0.064	.....	.....	.....	$0.396	0.606
Bitulithic on Concrete Base	130	0.171	.....	.....	.....	.....	.....	0.396	0.567
Sheet Asphalt on Concrete Base	120	0.235	.....	0.064	.....	.....	.....	0.396	0.695
Asphaltic Concrete Redress	124	.....	0.146	0.064	.....	.....	$0.089	.....	0.229
Bitulithic Redress	133	0.171	.....	.....	.....	.....	0.089	.....	0.260
Concrete Pavement (1-2-4 mix.)	104	.....	.....	.....	.....	.....	.....	.....	0.690
Hassam Class "B"	105	.....	.....	.....	.....	.....	.....	.....	0.604
Hassam Class "A"	105	.....	.....	.....	.....	.....	.....	.....	0.709

Asphaltic and Bitulithic Pavements: Cost of Grading, Hauling, Spreading, Rolling, etc., R. G. McMullen.

This paper, which has to be read in connection with the preceding one, covers the cost items of grading, making the road, hauling, scarifying, shaping, spreading, rolling, etc.

The cost of hauling is based on the ton basis, using auto trucks of five ton capacity (the cost of maintenance and operation of the trucks is given in detail). The writer states that a table of all detailed costs in cubic yards and square yards for the different Multnomah County roads has been drawn up and a copy has been filed with the Board of County Commissioners, so that it is now a public record and open to inspection; in the article, this table is not reproduced.

The total cost of laying a 6 in. concrete pavement has been found to be $1.05 per sq. yd. and the efficiency with which the building of concrete roads is now performed may be judged from the fact that of the total cost of the paving 70 per cent is the cost of materials, leaving 30 per cent, or a little over 30 cents per sq. yd. for the entire cost of labor, hauling of materials and the use of mechanical equipment on the job. In other words, the cost of raw material was $0.74, the cost of labor, $0.31, making a total of $1.05.

Ordinarily, the concrete pavement is 6 in. thick, while bituminous pavements are 2 in. thick, and the materials in the bituminous pavements are not so expensive as they are in the concrete pavement. The writer contends, therefore, that a 2 in. bituminous pavement can be laid for $0.60 per sq. yd., including overhead charges, etc., or an actual cost of $0.532. It must be remembered, however, that the above figures are not what the contractor's cost would be, but only the actual cost of laying the pavement and the question of "profits" (and also the cost of capital, etc., which the contractors have to take into consideration) has not been considered here.

Some of the speakers objected to the above figures as being too low, and pointed out several items which have been omitted, such as liability insurance, repairs to the plant, bond premiums, depreciation of the automobile trucks used in hauling materials, office expenses, plant site preparation, fire insurance, etc. As one of the speakers tersely stated, "for a contractor to omit any of these items would be fatal

and it would amount to just the difference between being able to accomplish a good job and break even, and getting in the hole and losing considerable money." (16 pp., *p.*)

BRITISH ASSOCIATION, MANCHESTER MEETING, SECTION G.

Testing Tool Steels, Professor A. B. Field.

The paper reports some data of an investigation of tool steels and cutting tools.

One of the first points to be determined was the degree of uniformity obtainable in the heat treatment of special tool steels, so that the results could be duplicated at will, and successive tools used for comparative operations could be depended upon to be uniformly similar. In this connection the dynamometer arrangement constructed by the late Doctor J. T. Nicholson, of the Manchester School of Technology, is of great interest. The forces exerted on the tip of the tool by the material being cut in ordinary heavy engineering work might easily exceed 10 tons, and it is necessary not only to measure forces of this order, but to do so without giving the tool sufficient freedom of motion to affect the cutting operation of the lathe. The first dynamometer made measured the most important component of the force, viz., that in the direction of the motion of the work relatively to the tool. The dynamometer which was used later measured the components of force in three directions at right angles to one another, and thus completely determined the resultant force on the tip of the tool, except that the exact point of application had necessarily to be estimated. That the tool could be given the necessary freedom for determining these three forces while it was making a cut in steel to a depth of 3/8 in. at a rate of feed of 1/8 in., with some six tons force on its tip, without impairing the normal operation of the cutting, may be considered a triumph.

More recently, a device has been constructed in the shops of the Manchester School of Technology for determining a corresponding system of forces which arises in the operation of a milling cutter. In this case, the forces exerted upon the work in both the tangential and radial directions were measured on a dynamometer, diagrammatic provision being made for a possible negative force and the axial force being measured on the milling spindle itself. In the laboratory of the same institution, a comparatively rapid method has been developed for determining the ultimate endurance to rapid reversals in the material by a short series of direct reversal tests upon each of half a dozen or so specimens of the material.

As the Proceedings of the British Association containing the above paper are not available, this abstract has been made from a report in *Page's Engineering Weekly*, vol. 27, no. 577, October 1, 1915.

INSTITUTION OF MECHANICAL ENGINEERS

Journal, no. 7, October 1915, London.

The Theory of Grinding, with Reference to the Selection of Speeds in Plain and Internal Work (abstract)
Struts and Tie-Rods in Motion, H. Mawson (abstracted)

The Theory of Grinding, with Reference to the Selection of Speeds in Plain and Internal Work, James J. Guest.

The question of the best work surface-speed in grinding is one which is constantly being raised, and there is a universally accepted belief that it should have some definite value dependent not only on the abrasive, grit, and grade of the wheel, but on the material of the work. Opinions and practice vary widely as to what this value should be, and for many years the values used have steadily lessened.

In the paper, the author puts forward his theory of grinding, which is based rationally upon a consideration of the action taking place between the wheel and the work and of the power involved. The conclusion first reached is that the quantity which the author terms the normal material velocity must lie between certain limits. In cylindrical work the value of the normal material velocity is $\sqrt{2v^2t\frac{d+D}{dD}}$ where d and D are the diameters of the work and the wheel respectively, v the work surface-velocity, and t the depth of the cut; the positive sign is to be taken for external and the negative for internal grinding. If this quantity exceeds a certain value which depends on the grit and grade of the wheel and on the material of the work, the wheel will wear away too rapidly; while if it be less than a certain other quantity, the wheel will glaze.

The fact that a machine is designed to take up to a certain amount of power, limits the value of vt for any particular grade of wheel; if vt has any less value than this, the machine is not utilizing the full power supply. By considering these two controlling factors in combination, the methods of efficient grinding are deduced. The best work surface-speed thus depends not only upon the material of the wheel and of the work, but also upon their diameters and the particular machine in use, and the current belief that it should have a fixed invariable value is shown to be fallacious.

The case of a piece of work already on the machine and causing trouble in the grinding is first considered. If the wheel is wearing too rapidly, it is natural to reduce the cross-feed to check it, a course which is efficacious but of bad economy. It has been discovered by experience that it is better to reduce the word-speed until the wheel wears well enough. The author, however, shows that the correct course is to reduce the work-speed much further and to increase the cross-feed simultaneously.

When, on any particular machine, work of various diameters is handled, or wheels of different diameters are used, the best work surface-speed is shown to be proportional to $\frac{dD}{d \pm D}$. By taking numerical examples of plain (external) grinding, it is found that work of small diameter should run at a slower surface-speed than is suitable for work of larger diameter; considerations of vibration and chatter, however, frequently render it necessary to use less force upon slender work, and this leads to an increase of this natural surface sp·ed. With work of large diameter, the formula leads to high surface-speeds combined with fine cross-feeds; the difficulty of using fine cross-feeds renders this undesirable, and it is proved that the way to overcome this trouble is to reduce the width of the wheel, which permits slower work surface-speeds and heavier cuts to be used.

The effect of wheel size and wear is then taken up; it is of little importance in plain (external) work, but lies at the root of the principal trouble in internal grinding, as it causes the

regime of the grinding to alter continuously. To secure the best output, the work-speed should be proportional to $\frac{dD}{d-D}$ in internal grinding, and the natural work-speed very high when the work is only a little less than the hole. The corresponding cross-feed will be small—so much so as to be unworkable, unless more power is used per inch of wheel-face than is the practice in external grinding. If the width of the wheel be selected so that the grinding can just take place, the wheel-face will be on the point of glazing. As it wears down in size, it at first works better, but afterwards commences to waste away. The work-speed should then be lowered and the depth of cut increased, which will alter the action so that the wheel again works well or tends to glaze according to the amount of the alteration.

The arc of contact, which is commonly supposed to be the important factor in internal grinding, has no direct effect. The area of contact, however, is shown to be a measure of the rate of removal of material, and in internal grinding a narrow wheel and a long arc of contact are necessary.

Change of wheel grade has a double effect. For a softer wheel, a smaller normal material velocity must be used, and at the asame time the value of vt increased for any particular machine. This leads to lower work surface-speeds and heavier cross-feeds. Combined with the increase of power per unit width of wheel-face, adopted in modern machinery with the view of increasing output, the result during recent years has been the continuous lowering of the work-speeds used.

The theory has been treated somewhat discursively in the author's book on grinding machinery, but in this paper it is presented logically and stripped of all adventitious matter; only the needful properties of the wheel are involved so that the application may be as broad as possible.

STRUTS AND TIE-RODS IN MOTION, H. Mawson

The author shows how the stresses in a rod which is in motion and subjected to an endlong force, may be calculated; he shows further that the formulae which have been derived for forces in stationary struts are only special cases of those obtained for rods in motion.

He takes first the case of a uniform circular shaft of a certain weight per unit of length, rotating at a speed (in radians per second) in bearings which do not constrain it in any way and assumes that it is subjected to an endlong compressive force. He derives an equation which shows that as the speed increases, the critical endlong force rapidly diminishes and that if the speed be zero, then we have a stationary strut, loaded with a certain weight per unit of length and the critical endlong force is found to be Euler's load. The same equation gives an expression for the critical speed of the shaft, which is found to decrease as the endlong compressive force increases. Moreover, when this force is zero, the equation gives an expression for the whirling speed of a shaft rotating in bearings and not subjected to any endlong force.

The author considers next the case of a rotating shaft subjected to an endlong tensile force F and derives an equation which gives an expression for the speed in radians and the endlong tensile force F, also showing that the greater the value of F, the greater the angular velocity has to be before whirling takes place; hence, the whirling might be prevented by applying an endlong tensile force to the rotating shaft.

Next the author takes the case of a uniform rod, every portion of which describes a vertical circle and is subjected to an endlong compressive force S. He discusses the three possible cases covering the relation between the position of the rod, weight and centrifugal force, and derives certain equations which, among other things, prove that a circular rod, rotating as a coupling rod and subjected to an endlong compressive force, will whirl at the same angular velocity as it would if rotating as a shaft and subjected to the same endlong force, no matter what the radius of the vertical circle may be, since the moment of inertia about all axes of bending is constant.

The same equation for the maximum stress has been applied to a particular locomotive coupling rod, which broke while in service, and the results are tabulated in Table 0. The particulars and dimensions relating to this rod (I-section) are as follows: Diameter of cylinder, 18 in.; working steam-pressure, 160 lb. per sq. in.; radius at which rod acts, 12 in.; distance between centers, 8 ft. 11 in.; diameter of wheels to which rod was attached, 6 ft. mean sectional area, 6.53 sq. in.; mean moment of inertia I, about the axes of bending, 12.5 in.^{4} units; mean weight per inch run, 1.85 lb. Calculations have been made for steam pressures of 160 and 200 lb. per sq. in. at different speeds of the engine, the direct stress $\frac{F}{A}$ being taken as the full steam pressure on the piston divided by the sectional area of the coupling rod.

It will be noticed that the stress increases very rapidly as the speed of the engine increases, and that at the high speeds an increase in steam pressure does not appear to have as disastrous an effect as an increase in speed. It is also seen that at 60 miles per hour, with the ordinary working pressure of 160 lb. per sq. in., the stress in the rod is 9.82 tons per sq. in., which is rather high considering that the stresses are of an alternating character, first compressive and then tensile. Should the wheels slip upon the rail, it is quite possible that they may revolve at a speed equivalent to 80 or more miles per hour, and the stresses may then exceed the elastic limit. The rods have been known to break in cases of derailment owing to the high speed with which they rotate in such cases.

The author cites the formulae for stresses in uniformly loaded coupling rods given by Professor Perry and Professor Unwin, and shows that while the results obtained by applying the Perry formula agreed very closely with the determinations obtained from the author's equation, the results from the Unwin formula give stresses considerably below them.

Since the derivation of stresses from the equation given by the author is laborious, he suggests another method which gives results in very close agreement with those derived from the equation above referred to. Considering the coupling rod to be subjected to a uniform load of $w_1 = w + \frac{w}{g}a^2r$ lb. per unit run, where w is the weight of unit length of the rod, the bending moment due to this $= \frac{w_1 l^2}{8}$

The stress due to this bending moment $= \frac{w_1 l^2}{8Z} = f_m$

The deflection at the center due to this uniform load is

$$\frac{5}{384}\frac{w_1 l^4}{EI} = \delta$$

The stress due to the pressure F acting at a distance δ from the axis $= \frac{F\delta}{Z} = f_n$

The direct stress $= \frac{F}{A} = f$

Total stress $= f + f_m + f_n$

Treating the rod in this manner, the results of Table 4 have been obtained for different speeds of the engine with the steam pressure at 160 and 200 lb. per sq. in. (11 pp., 3 figs., *tm*).

TABLE 4 STRESSES IN A COUPLING-ROD AS A FUNCTION OF SPEED OF ENGINE AND STEAM PRESSURE

Speed of Engine in miles per hour	Steam Pressure 160 lb. per sq. in.	Steam Pressure 200 lb. per sq. in.
	Stress in Rod Tons per sq. in.	Stress in Rod Tons per sq. in.
10	3.2	3.95
20	3.78	4.60
30	4.70	5.25
40	6.18	6.8
50	7.70	8.7
60	9.82	10.8
70	12.30	13.3
80	15.2	16.4

SCIENTIFIC SOCIETY OF THE ROYAL TECHNICAL COLLEGE, GLASGOW

SAFETY VALVES, D. MacNicoll.

As the original publications of the Society are not available, the abstract is taken from the reprint of the paper in the *Mechanical World* (London, vol. 58, nos. 1497 and 1499, September 10 and 24, 1915). The date of reading of the paper is not given.

With the advent of oil fuel in the British Navy, determinations of the sizes of safety valves based on a formula using coal as a factor, proved altogether inadequate. (The formula for the sizes of safety valves in the Board of Trade rules is derived from the area of fire grate and steam pressure and with the Admiralty, from the heating surface and steam pressure.)

The first oil fuel vessel in which trouble was experienced was H. M. S. *Cossack,* a torpedo boat destroyer. During the accumulation trial, the steam pressure rose to a dangerous extent with the pointer of the gage going up rapidly; to prevent an accident, the easing gear was applied. It was observed that it required only a very small additional lift to the valves, somewhere about $^1/_{64}$ in., to keep the accumulation pressure below the danger point, and that the pressure in discharge steam was excessive. These valves were quadruple, 3.625 in. diameter, with a discharge pipe of 7.25 in. bore. New valves were then fitted, also quadruple, but 3.75 in. in diameter, with two discharge pipes, each of 7.25 in. bore. This was found satisfactory.

Meanwhile Mr. Gibson, of Cammell, Laird & Company, carried out a series of interesting experiments on one of the original valves. A small steam cylinder, fitted with a piston, was mounted on the boiler shell in the vicinity of the safety valve and the piston attached to the easing gear in such a manner that when the piston moved upwards, the valve was eased. The bottom of the cylinder was connected with the discharge steam space of the safety valve, and the effect was that excessive pressure in the discharge steam space assisted the valve to lift instead of preventing it from doing so. Fig. 4A shows this arrangement. The trials were most satisfactory.

About the same time, another torpedo boat destroyer, H. M. S. *Swift,* was equipped with quadruple 3.375 in.

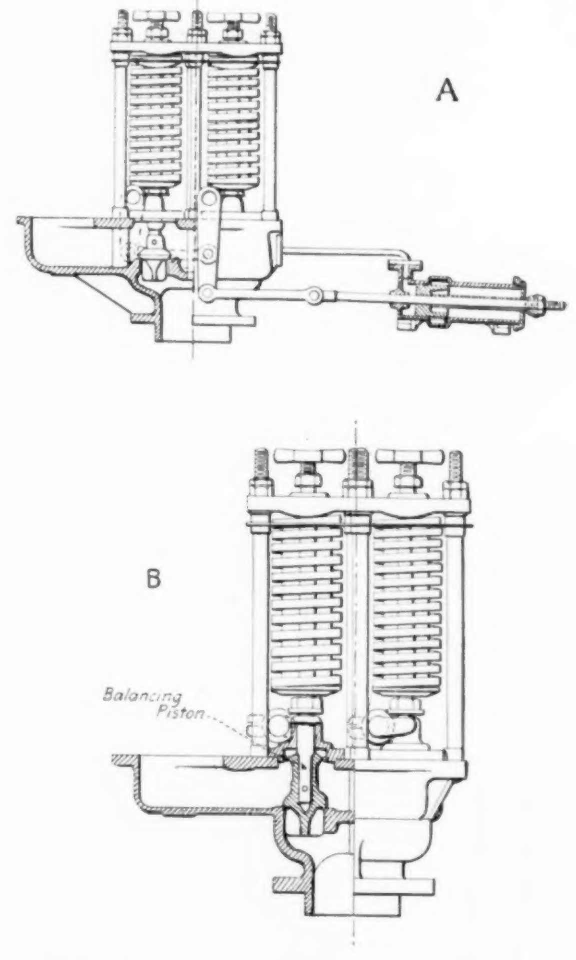


FIG. 4 SAFETY VALVES FOR OIL FIRED BOILERS (MARINE)

valves; but instead of having an external cylinder, each valve was fitted with a balancing piston or disc, which neutralized the effect of back pressure, (Fig. B). It proved entirely satisfactory, so far as the accumulation allowance was concerned, and it also proved that the size of the safety valve was sufficient, but that a much larger waste steam pipe would have to be used if no balancing arrangement was adopted. In consequence of the experience gained, the firm of Cockburns, of Cardonald, decided that in the future, for the Admiralty type of safety valve, they would determine the size of valves from the evaporation expected under accumulation conditions, and from that, the discharge pipe

area should be based on passing the evaporation at a pressure not exceeding 15 lb. pipe gage, or 30 lb. per sq. in. absolute. A large number of valves were constructed under these conditions with perfectly satisfactory results.

SOCIETY OF ENGINEERS

Vol. 6, nos. 8 and 9, August and September 1915, London

THE UTILIZATION OF SOLAR ENERGY, A. S. E. Ackermann

Discussion of the problem of utilization of solar energy as a source of motive power. A brief history of former efforts is given, among other things, the Willsie experiments at Pasadena, California, at Hardyville, Arizona, and St. Louis, Missouri. Four appendixes are given. Appendix 1 refers to the Shuman-Boys absorber in Egypt; in Appendix 2 the author derives the following equation of the theoretical efficiency of a solar heat absorber:

$$\eta = \frac{Dsa - pk(T^4 - {}^2/_3\,A^4) - (1 - r)Dsa}{Dsa}$$

where D is the width of the reflector in feet; p, the perimeter of the boiler in feet; r, the efficiency of silvered glass as a

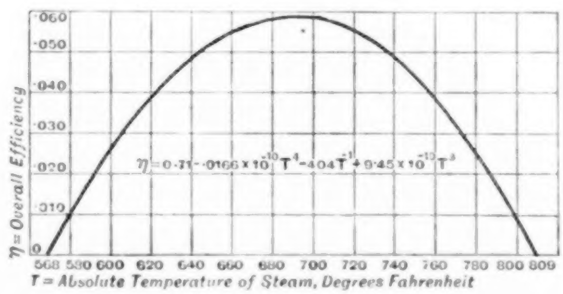


FIG. 5 CURVE SHOWING THE RELATION OF THE OVER-ALL EFFICIENCY OF THE 1913 SHUMAN-BOYS SUN-HEAT ABSORBER (WITH NAKED BOILER) COMBINED WITH A CARNOT ENGINE, TO THE ABSOLUTE TEMPERATURE OF THE BOILER STEAM

reflector of heat; s, the solar constant in B.t.u. per square foot per minute = 7.12; a, the coefficient of atmospheric transmission; T, absolute temperature of the boiler in deg. fahr.; A, absolute temperature of the reflectors in deg. fahr. The temperature A was found to be about 9 deg. fahr. above the shade temperature of atmosphere. The efficiencies thus calculated were compared with those obtained by experiment, and were shown to be rather higher.

In Appendix 3, the author demonstrated that the best commercial result on over-all efficiency obtained from a solar heat absorber and engine did not necessarily correspond with the maximum thermal efficiency of the absorber alone. The equation for the over-all efficiency of the plant is

$$\eta_o = \frac{[Dsa - pk(T^4 - {}^2/_3\,A^4) - (1 - r)Dsa]\ (T - 568)}{Dsa\ T}$$

where T is the absolute temperature of the steam and 568 the absolute temperature of the condenser in deg. fahr. (taken as constant), the other symbols having the same meanings as in the equation given in Appendix 2. Assuming the mirrors to have a temperature of 100 deg. fahr. and inserting the values of the other quantities (except T), the equation becomes:

$$\eta_o = 0.71 - 404\,T^{-1} + 9.45 \times 10^{-10}T^{3} - 1.664 \times 10^{-12}T^{4}$$

Differentiating this equation with regard to T, and equating the result to zero, the value of T is obtained, which gives the maximum over-all efficiency under the given conditions.

This being done, it is found that T = (231 — 461) deg. fahr., corresponding to a steam pressure of 21 lb. sq. in. abs. Inserting this value of T in the equation just given, the *theoretical* maximum over-all efficiency of the Meadi absorber, combined with a Carnot engine, is found to be 5.9 per cent., while the *actual* maximum was 4.32 per cent. The relative efficiency was thus 73.2 per cent. This means that nearly three-quarters of the boiler horse power theoretically possible under the stated conditions was obtained.

Instead of differentiating the equation to n, it is possible to insert various values of T, and thus calculate the corresponding values of η_o and plot the results. The value of T which gives the maximum commercial economy is then readily seen in the inspection to be 231 deg. fahr. as before, (Fig. 5). It is also seen that $\eta_o = O$ when T = 568 deg. fahr. (= T_2, the temperature of the condenser), or when T = 809 deg. fahr. The latter corresponds with a steam pressure of 131 lb. sq. in. abs., and means that the loss by radiation and conduction from the boilers and by the inefficiency of the mirrors would then be equal to the solar heat received.

Appendix 4 is a bibliography of the subject.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles in the Survey.

MEETINGS

MILWAUKEE, SEPTEMBER 1915

About 150 members and guests attended the opening meeting of the Milwaukee Section in September. Col. Henry A. Allen, Mem. Am. Soc. M. E. and consulting engineer for the City of Chicago, gave a very interesting, illustrated talk on Municipal Waste, describing very fully the development and present status of the garbage and ash handling in Chicago. He also gave a short talk on the Eastland disaster and dwelt quite fully on the stability of vessels. Col. Allen closed his talk with a description of the new Winslow high pressure steam boiler.

PROVIDENCE, SEPTEMBER 22

The opening meeting of the Providence Association of Mechanical Engineers was held in Engineering Building, Brown University, on Wednesday evening, September 22, at which F. H. Small presented a paper on the Manufacture of Leather Belting. Mr. Small has had a wide experience in this line and presented to the meeting an unusually interesting account of the various processes involved from the curing of the leather hides down to the selection of the proper size of a belt for any particular condition of driving. During the latter part of his address, he devoted considerable attention to many of the important but too little understood features of the proper application of leather belting in power transmission; he showed that, where oftentimes a belt drive has proved unsatisfactory a very slight change in the width or thickness of a belt will correct the fault and give the belt a very greatly increased life.

CINCINNATI, SEPTEMBER 30

A joint meeting of the Cincinnati Section of The American Society of Mechanical Engineers and the Engineers' Club of Cincinnati was held on the evening of September 30. John S. Crandell, formerly of the Highway Engineering Department of the Pennsylvania State College, spoke on Coal Tar Products and Road Building. The speaker began by carefully defining such terms as tar, bitumen, and asphalt. He discussed at some length the tar derivatives and the characteristics of coal-gas tar, water-gas tar, coke-oven tar and the characteristics of the various oils and pitches obtained from different coals, and from the same coals by varying the process. Retorts for distillation were illustrated by lantern slides. Some of the fundamental principles of road building were discussed by the speaker and the use of tar products in the top dressings of roads was elaborated in some detail. Various methods of forming the surfaces and distributing the pitch were illustrated by moving pictures. The paper was one of great interest and provoked considerable discussion.

The president of the Engineers' Club, who represented the club at a recent meeting of the Dixie Highway Commissioners at Chattanooga, gave a brief report of that meeting and showed on a map the various routes that had been decided upon, including the one through Cincinnati. About 75 members and guests were present.

NEW YORK, OCTOBER 12

The opening meeting of the New York local section was held on October 12, when a paper by Frank B. Gilbreth, Mem. Am. Soc. M. E., on Motion Study for Crippled Soldiers was presented by Robert T. Kent, Mem. Am. Soc. M. E. Edward Van Winkle, chairman of the section, presided at the meeting.

In carrying out his development of scientific management in industrial plants and hospitals, Mr. Gilbreth has recently spent several months in Germany, and while there he became much impressed with the great problem which will confront the world of training the millions of soldiers crippled by the war to resume their places in industrial life and become self-supporting. He has been asked to put the results of modern management in general, and motion study in particular, at the disposal of those in active charge of training the cripples.

The first step in adequate placement of men through motion study lies in visualizing the motions used, or necessary, in any given type of work. This is done by means of the simultaneous cycle motion charts, devised and used by Mr. Gilbreth, which record the inter-relation of the individual motions and cycles of motions used in any method of performing any piece of work. By analysis, he is able to work out from the charts new methods of doing a piece of work. Thus many types of work formerly considered possible only for the man in complete possession of all his members and faculties can be adapted to the maimed or crippled worker.

The data included in these charts are gathered through various methods of making motion studies. From these records are made motion models that make it possible for teacher and learner to visualize the desired motions.

By means of these methods, the selected elements of skill and experience can be transferred in a new syntheticized cycle of least waste, to crippled learners where it is often necessary to specialize on some particular sense training.

While this method of study is bringing in gratifying results, no great headway can be made with the crippled soldiers' problem without worldwide coöperation. Such coöperation has been forthcoming wherever interest has been aroused, but Mr. Gilbreth begs for more. He needs photographs, records, and histories of cases where cripples have been taught successfully to do work and he also needs suggestions for adaptations of machines, tools, and other equipment or surroundings to workers.

MILWAUKEE, OCTOBER 13

At a meeting of the Engineers Society of Milwaukee on October 13, H. J. Mauger delivered a very interesting talk on the Electric Heating Industry. The local electric light company sent over a rather complete line of heating and cooking apparatus, and several of the company's demonstrators were present who baked some cookies and broiled some steak. Mr. Mauger said that the local company has just adopted a rate of 2 cents per kw-hr. for cooking. He said that this would cost the average family from $2.00 to $3.00 per month for electric cooking.

BUFFALO, OCTOBER 13

On October 13, a joint meeting under the auspices of the American Institute of Electrical Engineers was held in Boston, following out a new scheme of coöperation among the Civil Engineers, the Electrical Engineers and the Mechanical Engineers. The subject was Load Dispatching as Handled by Large Electrical Power Distributors. Mr. P. Kent of the Boston Edison Company and Mr. Masters of the Boston Elevated Company presented papers and lantern slides. J. M. Cushing of the Electrical Engineers explained

the scheme of coöperation among the engineering societies. The guest of the evening was J. J. Carty, president of the American Institute of Electrical Engineers, who spoke on the value of engineering societies to its members.

BUFFALO, OCTOBER 20

On Wednesday evening, October 20, the Engineering Society of Buffalo held its first meeting at the Hotel Statler. A dinner was served at which about 150 members participated. After the dinner, W. B. Hunter, director of the Fitchburg (Mass.) High School, gave an address on The Training of Mechanics, laying special emphasis on the work that has been done with the Fitchburg coöperative system. This system consists in having relays of students, one relay in the High School, while the second relay is working in the shops. The succeeding week the two sets of students change places. This system is working out very successfully and there is no question that it is a step forward towards the solution of the problem of getting mechanics.

There was a discussion following the address. Over 200 members were present at this meeting.

MINNESOTA, OCTOBER 21

The regular meeting of the Minnesota Section was held at the University of Minnesota on October 21 at which Quincy A. Hall, Mem. Am. Soc. M. E., presented a paper on the History of the Panama Canal. This paper covered the time from the first activities of the French down to the present time. Mr. Hall was well qualified to handle the subject as he has spent six years in the Canal Zone as a testing engineer.

NECROLOGY

JOHN PARKER

John Parker was born in Mansfield, England, on March 28, 1864, and came to this country in 1887. For four years, he was employed in the drafting department of the Corliss Steam Engine Company in Providence, R. I., and in 1891, he accepted a position with the Brown and Sharpe Manufacturing Company. In 1893, he took active charge of their miller designing and in connection with this position also held that of assistant chief draftsman, 1895-1902. As assistant chief draftsman he developed executive ability in putting work through correctly and efficiently, and many patents were granted to him chiefly in connection with his work on millers. He was in charge of the miller designing for this company up to the time of his death, which occurred on July 23, 1915. He became a member of the Society in 1909.

JAMES P. TOLMAN

James P. Tolman was born in Boston, Mass., on November 7, 1847. He received his early education in the public schools of Boston and entered the Massachusetts Institute of Technology, from which he took the degree of Mining Engineer in 1868, which was the first class to be graduated from the Institute. In 1870, he became superintendent of the Silver Lake Cordage Company of Newtonville, Mass. He then organized the J. P. Tolman & Company in 1884 which manufactured braided cord. In 1888, the Samson Cordage Company in Shirley, Mass., was organized as successors of the J. P. Tolman Company and Mr. Tolman became president of the company, which position he held up to the time of his death. This company is one of the largest in the world manufacturing braided cord. Mr. Tolman became a member of the Society in 1894. He died at his home in West Newton, Mass., on July 28, 1915.

ARTHUR S. MANN

Arthur S. Mann was born in West Medway, Mass., on September 4, 1867. He received his early education in the schools of Medway and graduated from the Massachusetts Institute of Technology with the degree of S.B. in 1888. The first two years out of college were spent with the George F. Blake Manufacturing Company. Following this he was with the West End St. Railway Company in Boston, Mass. From 1892-1894, he was with the E. P. Allis Company of Milwaukee as mechanical engineer. In 1894, he started a machine shop with F. E. Lammert in Chicago, building special machinery and conducting a general engine repair trade. He was vice-president of this company up to the time of his death, although he had taken no active part in the business since 1897.

In 1897, he became engineer of construction of the Ninety-sixth Street power plant and operating chief engineer of the various plants for the Metropolitan Street Railway Company of New York City. In 1901, he accepted a position with the Sydney St. Railway Company in Australia as construction engineer of power plants. In 1903, he went with the General Electric Company in Schenectady, N. Y., where he was engineer in charge of construction of their power plants and of the steam, air and water distribution of their entire works. Also he was at the head of the installation of the new powdered coal system and had charge of the design of their new furnaces and boilers.

Mr. Mann became a member of the Society in 1900. He died on June 3, 1915.

PERSONALS

William I. Ballentine has resigned his position as general superintendent of the Link Belt Company's Indianapolis plants.

J. Ralph Bolgiano has severed his connection with the Taylor-Wharton Iron and Steel Company of High Bridge, N. J., and is now associated as an engineer with The Emerson Company of New York, efficiency engineers. He has been assigned to work in the Chillicothe, Ohio, works of the B. & O. S. W. R. R.

Frank L. Dalas has accepted a position with the Youngstown Sheet and Tube Company of Youngstown, Ohio, in the electrical and mechanical department for the new extension of the plant.

Frank H. Schubart, until recently connected with the engineering department of Wheeler Condenser and Engineering Company, Carteret, N. J., has been appointed district manager of the St. Louis territory of the Company.

Alfred E. Ballin has become associated with the McIntosh and Seymour Corporation, Auburn, N. Y., as general manager. He was formerly manager of the gas and oil engine department of the Snow Steam Pump Works, Buffalo, N. Y.

Thomas W. Harris, Jr., recently connected with the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., as assistant to the works steam engineer, has accepted a position with E. I. du Pont de Nemours and Company, Wilmington, Del., as assistant in the purchasing department.

Jean M. Allen has become associated with the Floesch Con-

struction Company, Inc., Cape Girardeau, Mo., as manager and engineer.

Percy C. Smith has resigned his position as sales manager and mechanical engineer for the Roto Company, Hartford, Conn., to accept the position of factory manager for the Maxim Silencer Company, Hartford, Conn.

STUDENT BRANCHES

CARNEGIE INSTITUTE OF TECHNOLOGY

The annual banquet and final meeting of the Carnegie Institute of Technology Student Branch was held on June 4, 1915. The following officers were elected: Benjamin Schwartz, president; L. W. Sherwood, vice-president; J. T. Eaton, secretary, and J. M. Guter, treasurer.

The business meeting was followed by a paper on Heat Transmission into Steam Boilers, by Henry Kreisinger of the United States Bureau of Mines. Mr. Kreisinger has been engaged in experimental work of this nature in the government laboratories for several years and is the author of a well known text book on the subject of boiler practice. Mr. Kreisinger opened his address by differentiating between the ordinary conception of a steam boiler as including the furnace, stack, etc., and the boiler as a steam generating unit, in which reference he treated it. He defined the problem of heat transmission as that of getting the heat from the gaseous products of combustion and the residue in the fuel bed, and into the boiler.

Mr. Kreisinger traced the path of the heat from the firebox through the intervening space, a layer of soot, the boiler plate itself, a layer of mud and scale and a layer of steam to the water itself. He went into detail concerning radiation, absorption, conduction and convection in this connection. His investigations have shown that the path of the heat from the fire to the boiler surface is the slowest. A chart made from the direct results of an experiment showed how the temperature drop in this part of the heat path is enormous in comparison with the other parts. The results also showed a drop of 2150 deg. fahr. from the fire to the boiler surface, a drop of 40 deg. through the metal tube, and a drop of 15 deg. through the layer of mud, scale and steam on the inside.

The next consideration was given to the possibility of increasing the rate of heat transmission into boilers and thereby increasing the capacity of given units. Three possibilities presented themselves: Increased initial temperature, increased density of the furnace gases and increased velocity of the furnace gases. The idea of increasing the density was given up because it opposed high initial temperature. Limits were assigned to the initial temperature and gas velocity because these conditions when extremely high are accompanied by great losses in the efficiency of the fuel.

A considerable part of the paper was given up to a description of the apparatus used in performing the experiments that led to these conclusions. The temperatures were measured by means of platinum, platinum-rhodium thermocouples. Those used inside the boiler were imbedded in the tube, and the one used for taking temperatures at different points in the flue was mounted on an eccentric at the end of the long rod. Every precaution was taken to avoid error and the known inaccuracies were taken into account in calculating the results.

Mr. Kreisinger defined true boiler efficiency as the ratio of the heat absorbed by the boiler divided by the heat available for absorption. The heat available for absorption being the part of the heat in the hot gases which is above the temperature of steam. He then showed how more rapid transmission into the boiler will increase the amount of heat that is absorbed and thereby increase the efficiency of the boiler.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College on October 12, the following papers were presented: The Value of Public Speaking to the Engineer, by Professor Emerson of the Public Speaking Department of the College; A Brief History of the A.S.M.E., by Dean A. A. Potter, Dean of the Engineering Division of the College, and The International Harvester Company's Gas Engine and Cream Separator Factory at Milwaukee, by Prof. W. W. Carlson, Professor of Shop Practice of the College. Professor Carlson described the route that the pig iron takes in the factory to the finished product and told of the many time saving devices which that company uses.

PENNYSLVANNIA STATE COLLEGE

The first meeting of the year of the Pennsylvania State College Student Branch was held on September 30, at which Professors Moyer and Mease gave talks on the object of the A.S.M.E. and benefits which could be derived from it. They together with Professors Diemer, Wood and Bates urged the students to keep in touch with the Society by subscribing to The Journal and requested that as many of the senior students as possible try for the Junior Prize which has been offered by the Society. Dean R. L. Sackett, the newly appointed head of the Engineering School, told of his desire to further the interest in the Student Branch and said that he would do all that he could to coöperate with it.

POLYTECHNIC INSTITUTE OF BROOKLYN

At the first meeting of the Student Branch of the Polytechnic Institute of Brooklyn, 30 new men were admitted to membership in the branch and Dr. M. C. Ihlseng, consulting professor of the Institute, was made an honorary member.

H. A. Brandt, chairman of the Branch, presented a paper on the Manufacture of Shrapnel. He described the intricacies of their manufacture and carefully explained the complex and difficult processes. Prof. W. D. Ennis of the Mechanical Engineering Department related his summer experiences with dynamite which he used on his farm for clearing away rocks and shattering hard clay to permit better drainage and for digging a ditch.

PURDUE UNIVERSITY

The opening meeting of the Purdue University Student Branch was held on October 2. The meeting was attended by 126 students and faculty and 38 applications for membership were received. Dean Benjamin, Prof. G. A. Young, honorary member of the branch, Prof. L. V. Ludy of the Engineering Laboratories and Prof. L. W. Wallace addressed the students on the advantages to engineering students of becoming affiliated with a student section of the Society, and urged them to join. They also spoke of the many opportunities and importance of belonging to an engineering society and the relation of the student section to the Society.

At a meeting of the branch on October 16, W. F. Borgerd addressed the meeting on Electric Starting and Lighting Devices for Automobiles. He explained the different systems in use on several of the most important cars. He laid stress on the generators used on starting devices and their faults from a repair-man's point of view, and said that the principal fault with them was the difficulty in getting the connection between the engine and the dynamo. Mr. Borgerd also spoke on the care of storage batteries especially during the winter.

RENSSELAER POLYTECHNIC INSTITUTE

The first regular meeting of the Rensselaer Polytechnic Institute Student Branch was held on September 30, at which the following officers were elected: J. B. Lincoln, president; K. Keefer, vice-president; J. W. Hartman, secretary, and R. D. Culver, secretary.

Following the business meeting, Howard E. Stevens spoke on Diesel Engines. Mr. Stevens confined his remarks to the two types of engines manufactured by the McIntosh and Seymour Corporation of Auburn, N. Y.

UNIVERSITY OF COLORADO

At the first regular meeting of the University of Colorado Student Branch on September 30, Prof. John A. Hunter,

Mem. Am. Soc. M.E., gave a review of the Spring Meeting of the Society at Buffalo. He also gave personal impressions of the various sessions and inspection tours and expressed his opinion of the value to be received from attendance at such a meeting. Later, other members of the Mechanical Engineering Faculty gave talks on interesting engineering undertakings and material encountered during the summer months, and mentioned opportunities for vacation work and experience open to students.

UNIVERSITY OF NEBRASKA

A meeting of the University of Nebraska Student Branch was held on October 7. The following committees were chosen: On new members, H. C. Edwards, R. B. Saxon, L. L. Sharp and I. F. Smith; on Posters to Advertise the A.S.M.E., J. W. Galloway and D. E. Stokke; on A.S.M.E. Smoker, J. C. Baker, W. C. Chapin and C. S. Spaulding; on student programs for A.S.M.E., H. F. Holtz and R. B. Gillespie.

Professor Hoffman, head of the Department of Mechanical Engineering, spoke on the success of the engineer and told of the value of technical papers in keeping posted in modern engineering ideas. He advised that each man join some national society of engineers after getting out of school as well as taking an active part in student branches while in school. He also emphasized the value of The Journal.

WASHINGTON UNIVERSITY

The student branch of Washington University held its first meeting of the year on October 12. The newly elected officers, consisting of Prof. E. L. Ohle, honorary chairman, John J. Summersby, chairman, W. H. Kurtz, vice-chairman, Edmond Siroky, secretary, and H. C. Keysor, treasurer, took up their respective duties. It was decided that student members be required to give papers before the branch; and if necessary the subjects are to be assigned by the executive committee.

Charles Proetz, a student, gave a talk on Carburetors and Mixing Valves in which he treated the history and present day practice in the design of carburetors. Although dwelling chiefly on American practice, he showed how it differed from that in Europe. The talk was made very interesting by specimens which he dissembled to show their parts. The talk was followed by discussions by Professor Ohle and Messrs. Brady, Meinholz and Siegerest.

WORCESTER POLYTECHNIC INSTITUTE

The first meeting of the college year of the Worcester Polytechnic Institute occurred on October 1. Prof. Charles M. Allen spoke on Experiments with Gasoline. He illustrated his remarks by many simple experiments, some of which were very dramatic and which impressed the audience as being quite dangerous. By a combination of experiments, he illustrated in an easily understood way just those things which are likely to occur when gasoline, kerosene and alcohol are handled ignorantly. He also called attention to some of the serious cases resulting from its ignorant use as reported in the daily press, explaining the sequences which must have taken place to give the resulting explosions. One of the most interesting experiments was "the four-cycle engine." A covered tin pail was used for a cylinder. A hole near the bottom of the can held an ordinary spark plug and a hole in the cover was closed by a small tin box which served as a piston. An atomizer made an excellent carburetor, the mixture being introduced into the cylinder through a hole near the bottom. Mixtures of varying richness were sent into the cylinder and the effect was noticed when the spark was produced and the little tin box ascended. The lecture was concluded with a "fire eating" experiment in which the lecturer lighted his breath after inhaling a quantity of gasoline vapor through a cigar. It should be added that Professor Allen "washed his hands" of all responsibility for the safety of anyone who might try to repeat his experiments.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. Stamps should be enclosed for forwarding applications.

286 Experienced designer familiar with machines, tools and jigs or forgings and pressed metal work. Location New York State. Apply by letter.

287 Manufacturing concern in the East wants capable designers and draftsmen with experience in the mechanical design of steam turbines. Special inducement for a leading designer and for squad leaders; also for a man with designing experience on condensers. Apply by letter, stating age, education, experience, salary desired, etc.

290 Mechanical draftsman experienced in the charge of a drafting room, and thoroughly familiar from practical experience with designing, erecting and handling machinery for elevating and conveying material in factories, warehouses, mills, mines, quarries, sand and gravel plants; also gravel washing and screening machinery; a complete knowledge of mechanical power transmitting machinery, and its installation. Correspondence will be kept strictly confidential. Give experience, addressing Lock Box 3097, San Francisco, Cal.

306 Large shop in Nashville, Tenn., desires engineer who is particularly well trained in electrical matters; work for present, mainly survey of shops to determine what future equipment is needed both in the shops and power plant. Salary $1200 to start.

307 Competent engineer to prepare estimates and cost sheets for manufacture of war munitions. Location New York.

308 Draftsman experienced in design, layout and construction of refrigerating and ice-making plants. Apply by letter, stating experience, salary expected, etc. Location Connecticut.

309 Appraisal engineers for series of plants devoted to various branches of industrial chemistry. It is desired to secure a force of engineers competent to take off quantities from the various plans, to verify the execution and to measure up the work in the buildings; fitness of the plant for its chemical purposes is not in question. Employment will last from two to three months; possibly subsequent employment for some members of the force on a more permanent basis.

314 Draftsman for wood factory building. Must be familiar with piping and belt drives. Apply by letter.

316 Superintendent or foreman competent to take charge of plant and experienced in every department required in the manufacture of rifles. Apply by letter.

318 High grade designer of machine tools; preference for a man who has had from 15 to 20 years' experience and one who is a practical shop man as well as a capable designer. Location Rochester, N. Y.

319 Sales engineer on steam turbines, centrifugal pumps, steam engines, hoisting machinery, feed water heaters, steam separators, etc. Apply by letter; location Pittsburgh.

321 Qualified engineer to conduct organization work for Canadian concern making all classes of fencing materials; one prepared to consider short term engagement. Apply by letter.

322 Assistant factory superintendent, one experienced in pump work. Location New York.

324 Three or four competent men to act as foremen in manufacturing plant, in assembling of mechanical parts of munitions. Salary $100 to $125 a month. Location New Jersey.

325 Paper mill engineer; must have initiative and be competent to take charge of all work in the mechanical engineering of a large paper mill. Applications should be accompanied by a statement of age, qualifications, and salary expected. Location Eastern Massachusetts.

329 Several expert mechanical draftsmen in ordnance work department. Location Maryland.

331 Designer, thoroughly familiar with design of firearms, especially gun stocks. Location New York.

334 Wanted time study man, preferably one having technical school training, subsequent machine shop experience, time study and efficiency work. It is essential that time study man be an experienced machine tool operator who can demonstrate any standards set by operating the machine tool. State fully training and experience, present position and minimum salary to start with this company. Location Buffalo, N. Y.

335 Partner wanted. Electrical engineer with experience and clientele will join mechanical engineer who is likewise equipped. Middle West preferred. Capital furnished and required. P. O. Box 617, Chicago.

339 Technical graduate or practical man with experience in design of gas and oil fired furnaces; structural iron work, especially foundations for machines subjected to heat; and structural steel containers for bulky material, as coal hoppers, etc. Apply by letter. Location New York.

345 Massachusetts manufacturer of small electrical apparatus, in quantities, requires the services of an assistant purchasing engineer for the inspection of incoming materials; applicant must be thoroughly familiar with electrical, insulating and composition casting materials, with practical knowledge of metal working and similar machinery; state details under headings of age, nationality, education, practical experience, salary, when at liberty.

346 Young engineer on development and sales of alloy steels as used in manufacture of automobiles and kindred purposes. Location Pennsylvania.

MEN AVAILABLE

The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

K-304 Member, M.E. and E.E., age 35, with nineteen years' practical experience in bolt and nut manufacture, rolling mills and tube mills, and light and heavy forging. A-1 on design and plant development. At present superintendent of agricultural forge works. Location lake or coast city. Salary $4000.

K-305 Young mechanical engineer with three years' experience desires position as assistant to refinery manager or superintendent of large petroleum company in vicinity of New York.

K-306 Member, technical graduate, age 36, experienced in design and construction of structural steel work, machine tools, shop layout and arrangement of machinery, efficiency management, accounting and costs, works management, planning and routing, orders and stores, and also with experience as sales engineer, desires to become associated with a shipbuilding concern or an allied industry. Prefers to locate in New York or Philadelphia.

K-307 Member, M.E., twenty years' varied practice in general engineering and capable of assuming responsibility and control, an experienced designer, and one who has traveled extensively, desires to get in touch with concern requiring a reliable man in executive shop or office position. Salary $3000.

K-308 Technical graduate, age 24, three years' experience, two in manufacture and design of hydraulic machinery, one in plant department of New York public service corporation, desires a position in the engineering department of manufacturing or operating company located in Middle West.

K-309 Technical graduate, wide experience as railway mechanical engineer, machinist, motive power draftsman and mechanical engineer, desires position along these lines, or one as mechanical inspector, assistant superintendent of motive power, or assistant to general manager. Location immaterial.

K-310 College man, both electrical and mechanical, with fourteen years' experience in engineer's office, textile and rubber factories and electric light company, desires position in engineering or mechanical department of some large industrial concern, with consulting engineer or electric lighting company.

K-311 Associate-member, age 34, with seven years' experience as designer, chief draftsman and assistant engineer in the automobile and gas engine line, and two years as designer of gasoline mine tractors and mining machinery in general, wishes position as chief draftsman or assistant engineer in concern manufacturing along these lines. Location preferred New York.

K-312 Member, graduate engineer, age 40, American, twenty years' experience as salesman and office manager for company making air moving machinery and power apparatus, well acquainted with manufacturing plants, engineers and architects in New York territory, wants sales representation for mechanical apparatus on salary, or salary and commission basis. Location New York.

K-313 Junior member, M.E., age 26, three and one half years' experience in railroad motive power and mechanical department work, desires position with railroad or locomotive manufacturer with chance for advancement. At present employed.

K-314 Member, technical graduate, with twelve years' experience and who has made tests on boilers, engines, stokers, etc., and who has advised on fuel and made plans and specifications for new work, desires position with private firm or consulting engineer to superintendent of production of power.

K-315 Mechanical engineer with several years' experience in pump business as designer and chief draftsman is open for position.

K-316 Graduate mechanical engineer, age 31, thoroughly experienced in modern publicity work as applied to products of a mechanical nature, is open for position as advertising manager. Replies are solicited only from high grade firms that believe in clean cut, dignified methods, and are willing to pay a suitable salary for capable service.

K-317 Sales engineer, district office manager or agent, technical graduate M.E., ten years' successful sales record handling power plant equipment and problems in power transmission, covering a wide field of industries, seeks similar position with greater opportunities. At present employed.

K-318 Member, who has had charge of some of the leading foundries of the country and is capable of handling any foundry proposition, desires position as ganeral manager or superintendent of foundry.

K-319 Junior member, Columbia graduate M.E., 1913, two years' experience in production and drafting department, desires position in New York with chance for advancement. At present employed.

K-320 Mechanical, electrical and structural engineer desires position of responsibility with electric power company, engineering concern or railroad company with chance of advancement. At present employed as assistant engineer of construction on two 15,000 kw. stations.

K-321 Member, mechanical and electrical engineer, age 37, married, technical graduate, fifteen years' experience chiefly in design, construction, and operation of power plants, street railways and heavy machinery, would prefer position as master mechanic, superintendent or chief engineer.

K-322 Member, seventeen years' experience, with ability to determine the most economical method of manufacture, and to supervise the design and building of tools, punches, and dies, milling fixtures, jigs and screw machine tools, or other equipment such as special machinery, and one who can determine cutting speeds and feeds and piece work rates, also the installation, care and maintenance of the power plant and transmission, desires position as master mechanic where experience would be of value.

K-323 Member, age 35, with an unusually thorough experience in rubber mill engineering, including developments, reports, designs, specifications and contracts for buildings, power requirements and manufacturing equipment, desires position with consulting engineer or large rubber mill. Salary $4000. At present employed.

K-324 Junior member, age 31, married, technical graduate in mechanical engineering, five years' experience in power plants, testing investigations, and general mill engineering, wishes position with progressive company as assistant works manager, mechanical engineer, or similar capacity. Would prefer to become associated with the automobile industry.

K-325 Member, with successful and satisfactory record and wide acquaintance among automobile and automobile parts manufacturers, now holding position as sales and advertising manager, desires similar position with company.

K-326 Member, fifteen years' experience as designing and executive engineer, has specialized in machine design, power economy and mill supervision, desires position. Specially qualified for paper mill work.

K-327 Member, technical graduate, age 30, ten years' experience in treating, testing and micro-structure of steel; practical knowledge of the treatment of steels to obtain best physical and machining properties; capable of eliminating all troubles in the working of steel and manufacture of steel products.

K-328 Member of the Society, technical education and shop experience, age 38, married, sixteen years' experience with two railroads and one locomotive manufacturer, designing and constructing locomotives, cars, automobiles, motor cars and special railway equipment, desires position with a railroad company.

K-329 Industrial engineer, analytical and creative ability of the highest order; excellent manager of help, experienced in textile, food and manufacturing plants, mine quarries and department stores.

K-330 Technical graduate, age 31, nine years' broad experience in designing, manufacturing and testing special machinery, also delicate instrument work, thoroughly familiar with drawing office methods, pattern, foundry and machine shop practice, good executive, can handle correspondence, and draw up specifications, desires a position. Location immaterial.

K-331 Member of the Society, eight years' practical experience in general mechanical engineering, and four years in the installation of scientific management, desires a position with a progressive concern as efficiency or production engineer.

K-332 Ordnance engineer, member, M.E. degree 1913, age 35, married, fourteen years' experience, five and one-half years in army ordnance department, three and one-half years captain of coast artillery, completed ordnance school of application, familiar with electrical machinery and gas engines, commended for management and also familiar with efficiency systems, desires administrative position in development of military manufacture.

K-333 Member, age 33, Cornell graduate, twelve years' experience in machinery manufacture, design, sales, installation and operation, at present sales manager in Chicago for large machinery corporation, would consider proposition to fill responsible executive position. Location immaterial.

K-334 Junior member, technical graduate, twelve years' experience as chief engineer, designing, estimating, constructing and selling steam engines and boilers, steel, plate work, elevated tanks and towers, and general foundry and machine work, successful sales record, desires position. Immediate salary secondary to good opportunity for advancement.

K-335 Professor of mechanical engineering in a Canadian University, technical graduate of A-1 U. S. institution, both M.E. and E.E. training, has held responsible position in large manufacturing plant as well as important U. S. government post as engineering expert, also has had four and one-half years' successful teaching experience, and is author of engineering text books and numerous technical articles, desires teaching position in U. S. college.

K-336 Mechanical engineer, age 28, six years' experience, four years including foundry, machine shop, drafting and testing; two years power and mill machinery, installation and maintenance, wishes position.

K-337 Member, age 37, wide experience in factory engineering and power plant design, construction and operation, desires position as mechanical engineer or master mechanic.

K-338 Junior member, M.E., age 28, five years' experience in construction and equipping of manufacturing, supply or importing or exporting house. Familiar with far Eastern market.

K-339 Mechanical engineer, American, Junior, capable of taking charge of test floor, erection work, power plant investigation, technical correspondence, factory maintenance and purchasing. Energetic and reliable; can speak German. At present employed.

K-340 Mechanical engineer, member, age 40, married, twenty-five years' experience in the design of engines and water tube boilers, together with the plant and equipment for their manufacture, along the latest and most efficient lines, experienced also in the production of forgings, both drop and press work, desires administrative position in the development of the manufacture of all classes of forgings.

K-341 Member, technical education, twenty years' experience as general manager and treasurer of engineering works, also in charge of sales department, thorough practical experience and application of labor saving machinery in foundries and machine shops in various lines of general engineering work.

K-342 Young man, age 24, graduate of Lehigh University, has had two years' shop experience, desires position in engineering department of a manufacturing concern. Location immaterial.

K-343 Graduate of Worcester Polytechnic Institute, has had some experience in cost and efficiency work, interested in factory management and cost finding, would like position with manufacturing concern.

K-344 Member, age 32, technical graduate, solicits representation of a reputable firm, in Philadelphia, or would accept responsible position in a mechanical engineering capacity.

K-345 Associate-member, age 35, M.E., 1907, ten years' experience, five years in designing ordnance equipment and

machinery at the United Staes Naval Gun Factory, Washington, D. C.; five years with war department on the design of heavy machinery, familiar with mechanical and electrical transmission of power. At present in charge of drafting force, but desires administrative position in the development of machinery and manufacture of ammunitions of war.

K-346 Member, Executive and Mechanical engineer, graduate Massachusetts Institute of Technology, wide experience in railway operations, manufacturing and purchasing, desires position. Member Am. Ry. M. M. A., S. A. E.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

Asphalt. Its history, manufacture and uses. Charles Ekstrand. Read before the Brooklyn Engineers' Club, May 13, 1915. Gift of author.

Atlantic Intra-Coastal Waterway. Official Survey Lines and present status of the work in its various sections. *Philadelphia, 1915.* Gift of Atlantic Deeper Waterways Association.

Catskill Water Supply. A general description. *Sept. 1915.* Gift of New York City Board of Water Supply.

New Jersey Board of Public Utility Commissioners. Financial and miscellaneous statistics compiled from the Annual Reports made by Public Utilities, 1913. *Union Hill, N. J. 1915.* Gift of New Jersey. Board of Public Utility Commissioners.

Results of Experiments on Sewer Pipe and Drain Tile, E. H. Beckstrand. Utah Engineering Experiment Station. Bulletin no. 7. *Salt Lake City, 1915.* Gift of E. H. Beckstrand.

Sound Steel Ingots and Rails, Sir Robert Hadfield and George K. Burgess. Reprinted from the Journal of Iron and Steel Institute, No. I, 1915. *London, 1915.* Gift of Sir Robert Hadfield.

Steam Boiler Economy, William Kent. Ed. 2. *New York, J. Wiley & Sons, 1915.* Gift of Publishers.

Fourteen years have elapsed since the issue of the first edition of Dr. Kent's book. Naturally this edition differs greatly from the former one. This is well shown by the author's summary of improvements in modern practice and the practical results obtained. The wealth of references makes this of especial value. W. P. C.

Ventilation of Subways and Subway Cars, Robert G. Klotz. *New York, 1915.* Gift of author.

Water Powers of Canada. Province of British Columbia, G. R. G. Conway. *Ottawa, 1915.*

——. The Prairie Provinces, Manitoba, Saskatchewan, Alberta, P. H. Mitchell. *Ottawa, 1915.* Gift of A. S. M. E.

Year Book of British Columbia and Manual of Provincial Information. Coronation Edition. *Victoria, 1911.* Gift of Sir Richard McBride.

EXCHANGES

American Society of Civil Engineers. Constitution and List of Members, February, 1915. *New York, 1915.*

Engineers' Society of Western Pennsylvania. List of Members, October, 1915. *Pittsburgh, 1915.*

Municipal Engineers of the City of New York, Proceedings 1914. *New York, 1915.*

TRADE CATALOGUES

American Blower Co. *Detroit, Mich.* Sirocco Service.

Chicago Pneumatic Tool Co. *Chicago, Ill.* Bulletin 216. "Hummer" self-rotating hammer drills. *Aug. 1915.*

Cleveland Twist Drill Co. *Cleveland, Ohio.* Drill Chips. *Sept. 1915.*

Flanner Water Tube Boiler Co. *Akron, Ohio.* Flanner Water Tube Boiler, description.

Flannery Bolt Co. *Pittsburgh, Pa.* Staybolts. *Sept. 1915.*

Gardner Machine Co. *Beloit, Wis.* Gardner Grinder. *May-Aug. 1915.*

Lea-Courtenay Co. *Newark, N. J.* Catalogue H-2. Centrifugal Pumps.

Stephens-Adamson Mfg. Co. *Aurora, Ill.* Labor Saver. *Sept. 1915.*

Under-Feed Stoker Co. of America. *Chicago, Ill.* Publicity Magazine. *Sept.-Oct. 1915.*

Valley Iron Works Co. *Appleton, Wis.* The Beater. *Sept. 1915.*

Walworth Mfg. Co. *Boston, Mass.* Walworth Log. *Sept.-Oct. 1915.*

Weston Electrical Instrument Co. *Newark, N. J.* Bulletin 2004. A. C. and D. C. Portable Voltmeters. *1915.*

—— 2002. Weston Portable A. C. and D. C. Wattmeters. *1915.*

—— 2003. A. C. and D. C. Portable Ammeters. *1915.*

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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[1] A complete list of the officers and committees of the Society will be found in the Year Book for 1915, and in the January and July 1915 issues of The Journal.